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Draft EIS for the HD Mountains Coalbed Methane Gas Field Development Project

U.S. Department of Agriculture
Forest Service
San Juan National Forest
Durango, Colorado

U.S. Department of Interior
Bureau of Land Management
San Juan Resource Area
Montrose District
Durango, Colorado

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DRAFT ENVIRONMENTAL IMPACT STATEMENT

for the

H.D. MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

PINE DISTRICT, SAN JUAN NATIONAL FOREST

Archuleta and La Plata Counties, Colorado

Type of Action: Administrative

Lead Agency: USDA - Forest Service

Cooperating Agency: USDI - Bureau of Land Management

Responsible Officials:

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Abstract: Three alternatives for the H.D. Mountains Coalbed Methane Gas Field Development Project for the 56,910 acre study area within the boundary of the San Juan National Forest are described and evaluated. The alternatives are: Alternative A, the "No Action Alternative" emphasis is on opportunities to complete and operate the existing wells; Alternative B, the "Proposal" emphasis is on opportunities to develop and operate 34 additional coalbed methane gas wells within the study area; and Alternative C, the "Current Direction Alternative" emphasis is on opportunities to develop and operate a total of 115 new coalbed methane gas wells within the study area.

Comments must be received by: APR 8 1991

Please retain your copy of this draft EIS. Unless the extent of public comment is such as to require that it be substantially revised, the final EIS is anticipated to be a supplement to this draft statement.

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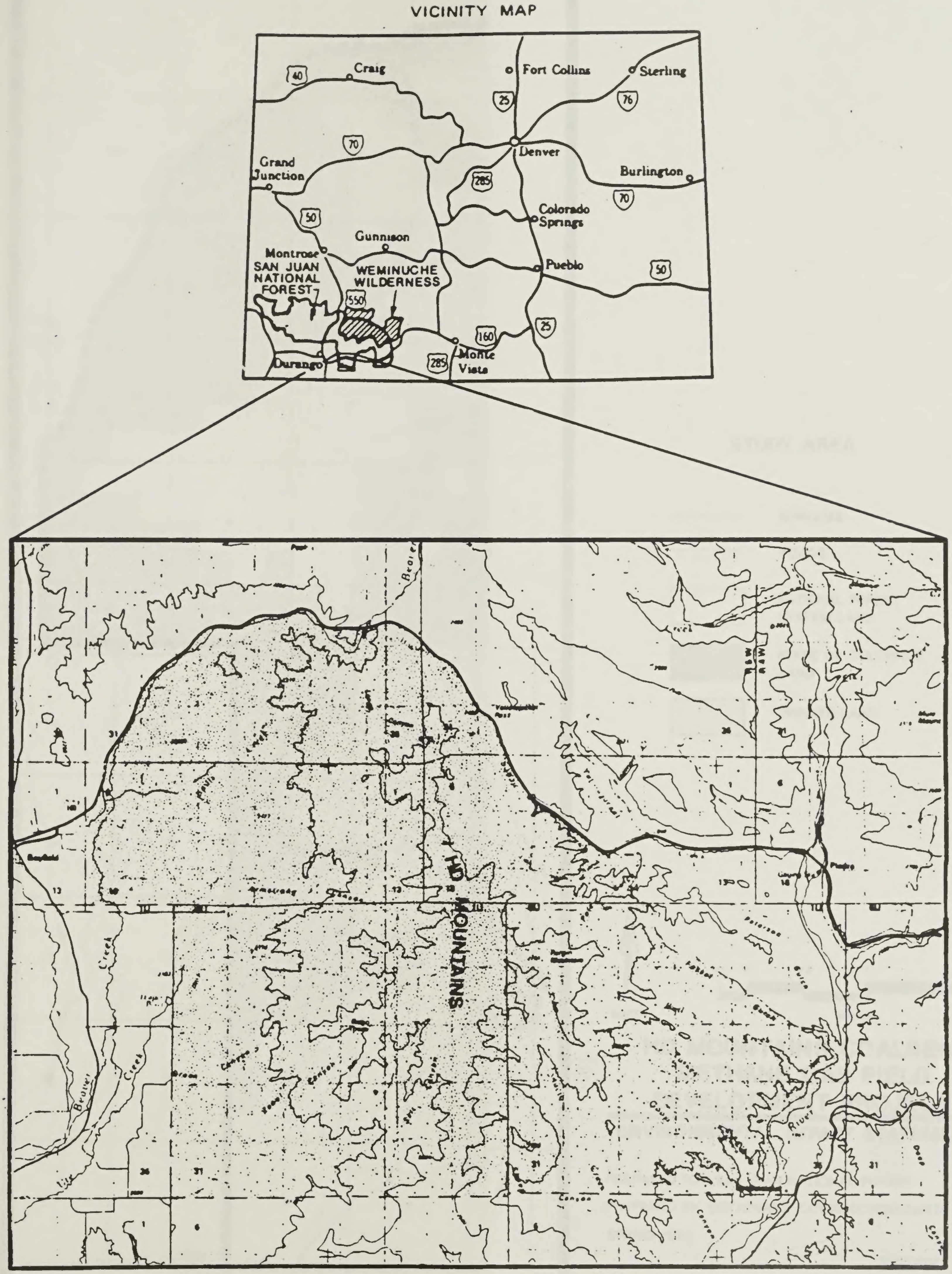
1.1 PROJECT LOCATION AND DESCRIPTION

The Amoco Production Company (Amoco) proposal to drill 34 coalbed methane (CBM) gas wells in the HD Mountains area, known as the HD Mountains Coalbed Methane Gas Field Development Project, is located within the proclaimed boundary of the San Juan National Forest east of Bayfield, Colorado (Figure 1-1). The Study Area for the proposed project occupies portions of Archuleta and La Plata Counties (Figure 1-2). Boundaries of the project's Study Area are U.S. Highway 160 and the Fosset Gulch Road to the north, the Piedra River to the east, and the Forest's proclaimed boundary to the south and west. The Study Area includes approximately 45,100 acres of National Forest System (NFS) lands, 11,450 acres of private lands, and 360 acres of state lands which total 56,910 acres for the entire Study Area. The proposed wells are located in the foothills of the HD Mountains on the western side (18 wells) and in the southeast corner of the Study Area (16 wells) on both private and NFS lands.

The proposed project involves construction of 34 well pads (six located on private lands and 28 on NFS lands, each averaging approximately three acres in size [Irving 1988]); construction of approximately 27.5 miles of new access road; drilling 34 coalbed methane wells; production testing for coalbed methane; construction of production water and methane gas flowlines; and reclamation of all areas not needed for production, including well pads and nonsystem access roads if the well is nonproductive. The planned drilling depths are between 2,200 feet and 2,800 feet below the surface. Amoco proposes to begin reconstruction and construction of new access roads and well pads by 1991. The wells proposed in the Sauls Creek area are anticipated to be developed first, with some activity also anticipated in the southeast corner of the HD Mountains in the vicinity of existing wells. It is further anticipated that the proposed well development activity would continue beyond 1991.

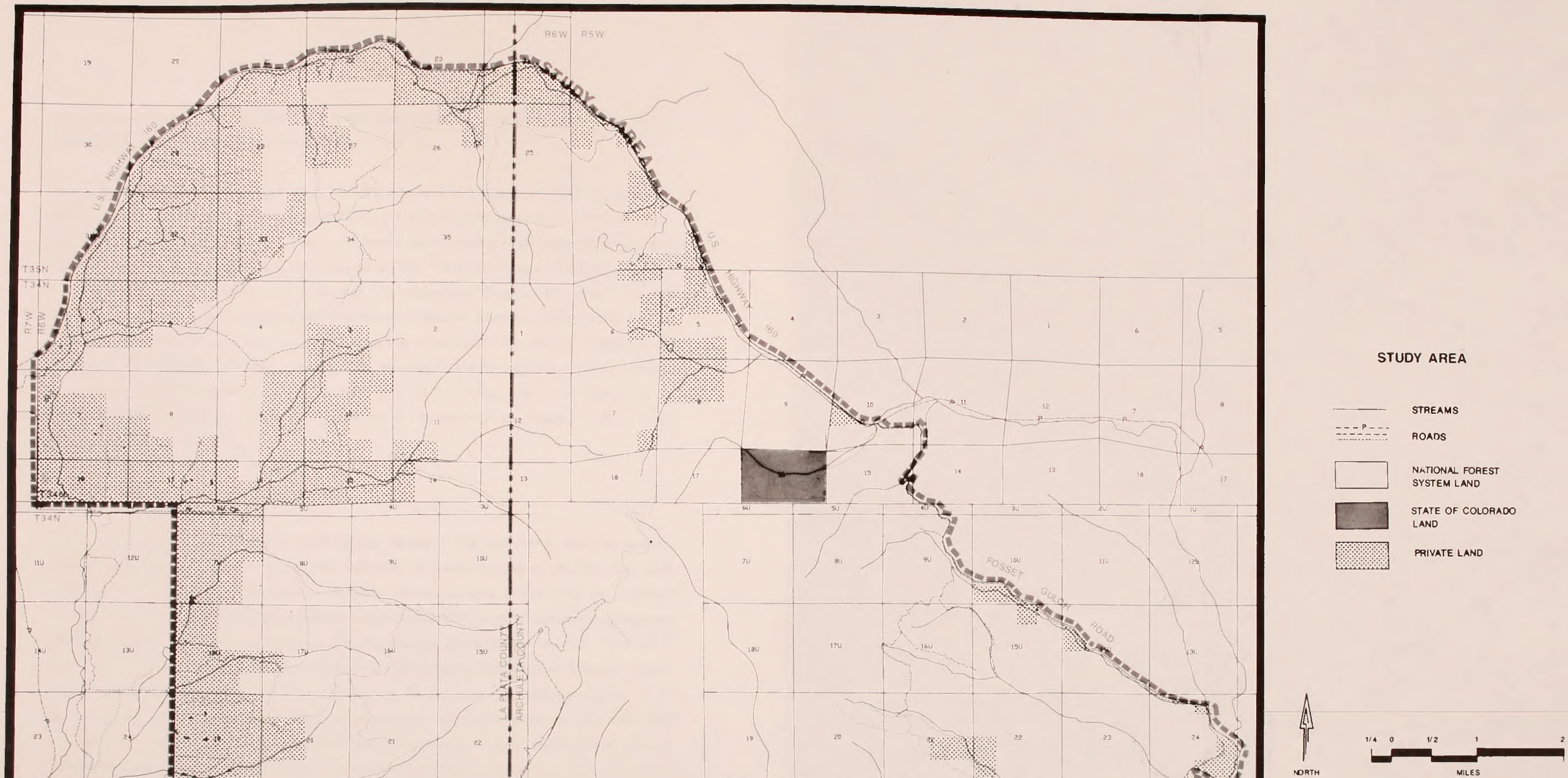
1.2 PURPOSE AND NEED FOR ACTION

Amoco has submitted Applications for Permit to Drill (APD) for five wells in the Sauls Creek area on the San Juan National Forest and submitted a map displaying the other potential wells they anticipate to be developed in the future in the HD Mountains (Pine District Files). The map is displayed as Alternative B



HD Mountains Coalbed Methane Gas Field Development Project Location

Figure 1-1



HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE I-2

(Figure 2-3) in Section 2.0. Once developed and tested, and if productive, the Sauls Creek wells would be connected to the existing gathering flowline system.

Private exploration and development of federal oil and gas leases is an integral part of U.S. Department of Interior (USDI), the Bureau of Land Management's (BLM) oil and gas leasing program under authority of the Mineral Leasing Act of 1920, as amended by the Federal Onshore Oil and Gas Leasing Reform Act of 1987 and the Federal Land Policy and Management Act of 1976. "The Forest Service (FS) considers mineral exploration and development to be an important part of its management program. It cooperates with the USDI in administering lawful exploration and development of leasable minerals. While the FS is mainly involved with surface resource management and protection, it recognizes that mineral exploration and development are ordinarily in the public interest and can be compatible in the long term, if not immediately, with the purposes for which the NFS land is managed" (FSM 2822.03 Policy). The Forest Service and the BLM's responsibility includes evaluating the proposal and it's alternatives in compliance with the National Environment Policy Act (NEPA).

1.3 ENVIRONMENTAL ANALYSIS PROCESS

The FS, as required by the Council for Environmental Quality (CEQ) and NEPA directives, analyzes proposed actions involving federal leases as to their impact on the human environment (40 CFR, Parts 1500-1508). The San Juan National Forest Land and Resource Management Plan (Forest Plan) was completed in September of 1983. The Plan's Environmental Impact Statement (EIS) contains a projection of expected drilling and production activities and describes the environmental effects of these activities. This EIS is directly tiered to the 1983 Forest Plan and the Forest Plan Final Environmental Impact Statement (FEIS) for the San Juan National Forest. The Forest Plan provides the long-range management direction for the Study Area. The plan also provides the management requirements that set the baseline conditions that must be maintained. These establish the environmental quality requirements, natural and depletable resource requirements, and mitigation measures that apply to all areas of the Forest. Any necessary additions to them are included in the management requirements for the individual Management Areas and are in addition to those listed as Forest Direction. The 1983 Plan and FEIS are hereby incorporated by reference. Site-specific information contained in this EIS will be used to make decisions on surface use plans of operations, road access routes, and pipeline/flowline locations on NFS lands within the project area.

The U.S. Department of Agriculture (USDA), Forest Service, Durango, Colorado, is the lead agency and is responsible for the EIS. The BLM, San Juan Resource Area of the Montrose District, Durango,

Colorado, is a cooperating agency. The evaluation of this proposal, including alternatives, was developed through interdisciplinary review with representatives from Amoco, FS, BLM and the Colorado Division of Wildlife (CDOW). Interdisciplinary participation was provided by a third party contractor, a private consultant working under the direction of, and in cooperation with, the FS.

This EIS provides the decision makers with information upon which to base a final decision that is fully informed and considers all factors relevant to the proposal. It also serves as a summary documentation of analysis directed at the proposal and alternatives in order to identify environmental impacts and mitigation measures necessary to address pertinent issues.

The decisions to be made during the environmental analysis process regarding the Amoco proposal involve the following:

- A determination of whether the drilling proposals can be conducted in accordance with stipulations contained in the leases (Refer to Section 1.4.2 - Lease Stipulations).

- A determination of whether or not the proposal is in conformance with FS and BLM policies, regulations, and approved land management direction pertaining to oil and gas exploration and development activities.

- A determination of whether a location for a drill site and access route exists that would be environmentally suitable, meets the needs of other resource management activities, acceptably mitigates surface resource impacts, and honors Amoco's lease rights.

- A determination of specific requirements to be included in individual surface use plans of operation.

This EIS is not a decision document. It is the result of a process used to document the effects of the proposal and the alternatives. The decision regarding the proposal will be documented in a Record of Decision signed by the responsible officials. The FS and BLM decisions will relate only to land administered by the FS. Decisions by other jurisdictions to issue or not to issue approvals related to this proposal may be aided by the disclosure of impacts available in this analysis.

1.4 LAND STATUS, LEGAL, AND POLICY CONSIDERATIONS

1.4.1 Land Status

The surface area within the study boundary, which includes Amoco's proposal, is primarily under the administrative jurisdiction of the FS, with some private inholdings. The mineral estate of the NFS land is under the administrative jurisdiction of the BLM. The private inholdings mineral estate, which has been leased in the private sector, is under the administrative jurisdiction of the Colorado Oil and Gas Conservation Commission (COGCC) (Figure 1-2).

All NFS lands within the Study Area have been determined to be leasable. This determination was made upon completion of environmental analysis prior to leasing. The Land and Resource Management Plan's EIS (FS 1983) for the San Juan National Forest reaffirmed this decision. The reaffirmation was based on the availability for leasing (i.e., land not withdrawn from mineral entry. For example, all classified wilderness areas have been withdrawn since January 1, 1984). These lands were identified as capable of having a medium to high potential for leasing which in turn reflected the area's potential for reclamation and restoration.

1.4.2 Lease Stipulations

The Amoco HD Mountains Coalbed Methane Gas Project involves numerous leases. The NFS lands within the Study Area are essentially all leased. The leases contain the following stipulations:

- Stipulations for Land Under Jurisdiction of the USDA - Form 3109-3. (Requires compliance with USDA's rules and regulations on NFS lands.)

- Surface Disturbance Stipulation (requires that surface disturbing operations receive prior agency approval). This stipulation also requires an environmental analysis of impacts. Upon completion of the environmental analysis, any mitigation measures to which the proposed surface disturbing operations will be subject will be attached to the Application for Permit to Drill, Deepen, or Plug back (APD) as Conditions of Approval.

- Supplemental Stipulation to Stipulation for Land Under the Jurisdiction of the USDA supplement to Form 3109-3. (Provides protection for existing roads, trails, streams, improvements, and cultural resources by establishing limited distances for site occupancy.)

The second stipulation prohibits entrance onto the lease area and any site-disturbing activities until either: (a) an inventory of archaeological, paleontological, and historical sites has been made by the surface management agency or its designated representative, or (b) the lessee had made or caused to be made an inventory of all archaeological, paleontological, and historic sites in those areas of the lease subject to development, occupancy, or surface disturbance.

The lease agreements identified areas of No Surface Occupancy (NSO) on some of the leases within the Study Area. The NSO was rescinded in 1981 and documented in a Decision Notice and FEIS for the Roadless Area Review Evaluation II. That decision was reaffirmed in the Decision Notice for the FEIS for the Forest Plan which identified the land as available for resource management activities, including roading.

Some leases also contain the following stipulation:

- Limited Surface Use Stipulation - This stipulation permits occupancy in the period from May 1 to November 15 for the purpose of protecting wintering wildlife.

1.5 AUTHORIZING ACTIONS

The federal, state, county, and local authorizing (permitting) actions required to implement any of the alternatives would generally be the same regardless of the alternative selected. These actions are listed in Table 1-1.

1.6 ISSUES AND CONCERNS

A variety of environmental, social, economic, and procedural issues and concerns have been raised about the coalbed methane gas development in the HD Mountains. FS, BLM, and CDOW resource specialists have identified some issues and concerns. Through a scoping document, numerous newspaper articles, public notices, a notice in the Federal Register, and two public scoping meetings, members of the general public have responded and identified many other issues and have helped to better define these issues and concerns.

TABLE 1-1
FEDERAL, STATE, AND COUNTY AUTHORIZING ACTIONS

Issuing Agency/ Permit Name	Basis for Permit	Authority	Appropriate Project Plan
FEDERAL PERMITS, APPROVALS, AND AUTHORIZING ACTIONS			
U.S. Department of Agriculture (U.S. Forest Service)			
1. Timber Sales Contract	Accounts for timber, cut, affected during mineral-related activities.	National Forest Management Act of 1976 (16 U.S.C. 472a) and 36 CFR Parts 221 and 223.	All proposed action and alternative surface disturbing activities on NFS lands.
2. Special Use Authorization	Occupancy or use of NFS lands such as rights of way off of leased lands.	National Forest Management Act of 1976 (16 U.S.C. 472a) and 36 CFR Parts 221 and 223.	All proposed action and alternative surface disturbing activities on NFS lands, outside of lease boundaries.
3. Federal Antiquities Permit	All archaeological investigations on public lands.	Archeological Resources Protection act of 1979 (16 U.S.C. 470); 36 CFR Part 1215.	All proposed action and alternative surface disturbing activities.
4. Surface Use Plan of Operations	Occupancy or use of NFS leased land sin conjunction with all oil and gas operations.	Federal Onshore Oil and Gas Leasing Reform Act of 1987. (16 U.S.C. 478, 551) 36 CFR Part 228.	All proposed action and alternative surface disturbance activities on NFS leased lands.
U.S. Department of Interior (Bureau of Land Management)			
5. Permit to Drill, Deepen or Plug Back (APD)	Provide for compliance with regulations and requirements during the drilling phase of the well.	Mineral Leasing Act of 1920 (30 U.S.C. 181 et seq.) 43 CFR 3160. Federal Onshore Oil and Gas Leasing Reform Act of 1987. 43 CFR Part 3160.	
6. Approval of Unitization	Provides for efficient and timely development and production of Federal oil and gas leases.	Mineral Leasing Act of 1920 (30 U.S.C. 181 et seq.) 43 CFR Part 3180.	Pargin Mountain Unit.

TABLE 1-1
(Continued)

Issuing Agency/ Permit Name	Basis for Permit	Authority	Appropriate Project Plan
U.S. Department of Interior (U.S. Fish and Wildlife Service)			
7. Consultation Process, Endangered or Threatened Species	Preliminary Biological Assessment	Sec. 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. Sec 1344; 33 CFR Parts 323 and 325.	All proposed action and alternative surface disturbing activities.
Department of Defense (U.S. Army Corps of Engineers)			
8. Permit for Dredged or Fill Material (404 Permit)	Placement of fill or dredged material in waters of the United States or adjacent wetlands.	Sec. 404 of the Clean Water Act (40 CFR Parts 122-123); 33 U.S.C. Sec. 1344; 33 CFR Parts 323 and 325.	All proposed action and alternative surface disturbing activities.
Environmental Protection Agency			
9. Produced Water Disposal	Underground injection of produced water.	Safe Drinking Water Act (42 U.S.C. 300F-300-9; 40 CFR Parts 144 and 147);	Underground injection control on NFS lands.
	Surface discharge of produced water.	Sec. 402 of the Clean Water Act (40 CFR Part 122)	Surface discharge of produced water on NFS lands.
STATE PERMITS, APPROVALS AND AUTHORIZING ACTIONS			
Colorado Department of Health			
10. Air Pollutant Emissions Permit (non-PSD)	Permits for emissions from new or modified sources.	CRS 25-7-112; 5 CCR 1001-5.	All fuel burning sources associated with proposed action or alternative.
11. Open Burning Permit	Control of all open burning.	CRS 25-7-123; 5 CCR 1001-3 Reg. No. 1, Section II.C.	Any open burning.

TABLE 1-1
(Continued)

Issuing Agency/ Permit Name	Basis for Permit	Authority	Appropriate Project Plan
12. Pollutant Discharge System Permit	Issue permits for surface discharge of any pollutant.	CRS 25-8-501 through 508; 5 CCR 1002-2.	Any point-source surface discharge.
Colorado Department of Highways			
13. Transport Permit	Permits for oversize, over-length and overweight loads.	CRS 42-4-409; 2 CCR 602-4.	Transportation of equipment and materials on State roads.
14. Application to Store and Use Explosives	Permit to use, store or transport explosives.	CRS 34-47-104; 34-27-101; 2 CCR 403-1, 403-2.	All proposed action and alternative activities requiring the use of explosives.
15. Permit to Drill, Deepen or Re-Enter and Operate an Oil and Gas Well	State approval of drilling on all non-federal lands within the State.	CRS 1973, 34-60-106(2)(d) and 34-60-106(9).	Wells.
16. Permit for Underground Disposal of Water	Regulates underground injection wells.	CRS 1973, 34-60-106(2)(d) and 34-60-106(9).	UIC wells.
17. Safety Regulations for Oil and Gas Activities	Regulates oil and gas activities to protect public safety.	CRS 34-60-106 (10)(11); Oil and Gas Conservation Commission Order No. 1-34.	All proposed action and alternative components.
LOCAL PERMITS, APPROVALS, AND AUTHORIZING ACTIONS			
La Plata County			
18. Special Use Permit[1]	Permit for extraction and processing on private lands.	Land Development Code.	All proposed action and alternative components in La Plata County
19. Road Use Permit	Overweight and overlength loads on County roads.	Land Development Code.	Transportation of equipment and materials on County roads.

[1] Under Court Appeal

Scoping for this project began on November 3, 1988 when a scoping document was mailed to 70 interested publics and made available at the Pine Ranger Station Office. The document described the existing situation of coalbed methane gas development in the HD Mountains on the Pine Ranger District and discussed the reasonably foreseeable future of gas development. The public was asked to provide comments. Along with the scoping document, newspaper articles on the same subject appeared in the Durango Herald and Pine River Times in mid-November, 1988. As a result, the FS received 41 written responses and a petition that was signed by 51 individuals.

Further public notification on the gas development subject and the public scoping process was discussed in a FS insert to the Durango Herald and Pine River Times in late January, 1989 and early March, 1989, respectively. Additionally, the Pine Ranger District Newspaper which addressed the same subjects was included as an insert in the Pine River Times in late March, 1989. The Pine River Times has about 1,300 local subscribers.

As a result of Amoco's proposal, public responses, and FS and BLM discussions on coalbed methane gas development, a Notice of Intent (NOI) to prepare an EIS was published in the Federal Register on April 18, 1989. A news release was prepared and distributed on April 19, 1989. A letter from the FS to interested publics was prepared and mailed on April 25, 1989 to 92 individuals, organizations, and businesses.

The late April news release and letter notified the public of a May 4, 1989 public scoping meeting to discuss issues and concerns for the EIS on coalbed methane gas development in the HD Mountains. Subsequent newspaper articles and a Letter to the Editor on the same subject were published in the Pine River Times on April 27 and May 4, 1989, and in the Durango Herald on April 30 and May 4, 1989.

A public scoping meeting was held on May 4, 1989, in Bayfield, Colorado to discuss public issues and concerns on coalbed methane gas development in the HD Mountains for the EIS. About 20 to 25 members of the public attended and participated in the meeting. Due to public comments regarding the short notice for this scoping meeting and their subsequent lack of preparation time, a second public scoping meeting was scheduled for mid-June 1989. The minutes of this May 4, 1989, meeting were distributed to all who attended.

A newspaper article on the first public meeting was printed in the Pine River Times on May 11, 1989. As agreed to at the public meeting, the Pine District Ranger coordinated the next public meeting date with several members of the public, particularly the San Juan Citizens Alliance. After a date was agreed to by

all parties (June 15, 1989), the FS published Public Notices in the Durango Herald, Pine River Times, and the Pagosa Springs Sun in mid-May, 1989 to allow time for the public to prepare for the meeting. The Public Notice was also posted at the Bayfield Post Office from May 15 to June 17, 1989. On May 16, 1989, the Pine District Ranger and several members of the public (i.e., San Juan Citizens Alliance) met, as agreed to at the first public meeting, to prepare the agenda for the second public meeting. The FS also agreed to have representatives of Woodward-Clyde Consultants (WCC), who were helping to prepare the EIS for the FS and BLM, present at the second public meeting. Additionally, newspaper articles in the Pine River Times and Durango Herald announced the June 15 meeting throughout early and mid-June.

The second public scoping meeting was held on June 15, 1989, again in Bayfield, Colorado. At this meeting, approximately 35 to 40 members of the public attended and participated. Public input on issues and concerns for the EIS on coalbed methane gas development in the HD Mountains for 1990 and beyond were taken. At this meeting, the public was also asked to comment on two Environmental Assessments (EAs) that were to be prepared in 1989 to evaluate the development of six gas wells in the HD Mountains. Minutes of the June 15, 1989 meeting were distributed to all who attended.

As a result of the two public meetings, 16 written responses were received on the EIS. Throughout the summer and fall, 1989 and winter, 1990, an additional 16 written responses were directed at the EAs being prepared by the FS and BLM. These 16 additional responses have been analyzed and included in the issues and concerns that appear later in this section.

All 73 written responses have been analyzed and included in the list of issues and concerns that follow. WCC has been provided with these public comments, along with the minutes to the public meetings, to better prepare this EIS. All written responses are available at the Pine Ranger Station for review by the public.

Environmental, social, and NEPA process issues and concerns of importance identified for the proposed alternatives are as follows:

1. **Gas development would harm big game (deer and elk) and other wildlife species, and indirectly impact private land and existing habitat improvement projects.**

   Numerous individuals commented that wintering elk and deer would be harmed by loss of habitat and disturbance due to well pad and road construction, trucking of produced water, and

any permitted public winter use of newly constructed roads. Some commenters indicated that truck traffic, noise from pumpjacks and trucks, and the presence of gas workers are stressing, harassing, and displacing deer and elk herds in the Sauls Creek area. The displacement area is greater than the road and well pad acreage. Others were concerned about negative effects to deer and elk in forms of abandoned ranges, declines in overall animal conditions, and declines in reproduction rates and stresses in calving areas. They felt that the EIS should examine amounts of drilling and maintenance activity on a seasonal basis, locations and total lengths of roads, and road use restrictions and closures.

Some expressed concern about increased road kills of big game due to disturbance, displacement, and greater human activity on the Forest. Others believe that there would be greater game damage to private land adjacent to the Forest. An individual wondered about the effects of gas development on the water table in relation to springs for wildlife water.

Concerns about the FS's and CDOW's substantial investments in habitat improvements on the Forest were made. Because of gas development, big game may not or would not use these improved habitats. Depending on the level of gas development allowed in the HD Mountains, the CDOW may not want to fund any cooperative habitat improvement projects.

Some individuals felt that resident and migratory wildlife other than big game (such as turkeys, migratory birds, lions, etc.) would be harmed by loss of habitat and disturbance from the same factors as those affecting big game.

2. **Coalbed methane gas development would degrade quality or reduce quantities of ground water in the area.**

Numerous commenters expressed concern that coalbed methane gas wells, produced water disposal wells, flowlines, spills of drilling fluids, and abandoned gas wells would degrade the water quality or reduce the quantity of private drinking water wells. Some cited reports of contaminated drinking water wells in the Cedar Hills area of New Mexico. Several of these questions were:

- Could coalbed methane gas wells contaminate shallow drinking water wells with methane gas?

- Could drilling fluids contaminate ground water from shallow freshwater aquifers by direct leakage from the well hole during the drilling operation?

- Could drilling fluids and produced, disposal water seep from holding or evaporation pits on the ground surface downward into shallow, freshwater aquifers?

- Could coalbed methane gas wells leak salts or other contaminants (i.e., hydrocarbons) directly into shallow, freshwater aquifers from produced fluids escaping through the gas well casings and cement linings?

- Could ground water and methane gas withdrawn from the Fruitland Formation be replaced by other ground water from overlying formations and thus deplete overlying ground water supplies?

- What is the likelihood that water disposed into deep formations from disposal wells would move upward into freshwater aquifers and contaminate them with salts?

- Could cathodic protection wells cause salty, poor quality ground water to contaminate drinking water wells?

Some commenters believe that the COGCC rules do a good job of protecting drinking water aquifers in the gas well drilling process and seismic testing. However, these rules do not (1) provide the same protection for wells drilled for cathodic protection purposes, and (2) address the effects of removing large amounts of water from immediately beneath freshwater aquifers in a spaced pattern over a prolonged period of time. These individuals requested that adequate documentation be provided in the EIS to demonstrate environmental safeguards to protect ground water. Some requested that the FS establish baseline information on water quality and quantity of private drinking water wells near the Forest.

Other commenters wondered if their water wells would decrease in quality or quantity, and who would compensate them for their loss. They questioned whether the private landowner should be solely responsible for testing water quality or quantity. They felt that monitoring of the water quality and quantity of nearby, private drinking water wells should be required

by the gas companies that are drilling the gas wells. If the drinking water wells are degraded in quality or reduced in quantity, then the gas companies should be held liable for damages.

3. **Gas development would degrade the quality or reduce the quantity of surface water, and harm fisheries.**

Commenters were concerned about the effects of any surface disturbing activity from gas development on surface water quality and quantity. They were also concerned about spills of produced water (both from water trucks and wells) and spills of fluids and drilling muds from fueling sites, reserve pits, and wells on surface water quality. The effects of alternatives to underground disposal of produced water, such as evaporation and surface discharge, need to be examined in the EIS. They suggested that the EIS be reviewed by the state agency responsible for nonpoint pollution. Also, one commenter asked that the EIS include the health effects from any solid waste disposal onsite.

One commenter requested that the EIS evaluate any possible contamination of a wetland or floodplain food chain, or the construction of structures in a floodplain. Another individual was concerned about the impact to fisheries from gas development in the HD Mountains.

4. **Coalbed methane gas development may damage the archaeological resources of the HD Mountains.**

Several individuals expressed concern about the potential for significant damage to any archaeological sites and ruins from gas development in the HD Mountains. They feel that it may endanger the potential listing of any cultural site on the National Register of Historic Places (NRHP). Some requested that Armstrong Canyon be nominated in the EIS for inclusion on the NRHP. They cited several archaeological surveys and studies to support this request. Another was concerned about effects of the HD Mountains gas development on Chimney Rock.

An individual expressed concern that no archaeological survey of the ground surface can adequately protect the cultural resources, particularly for subsurface archaeological sites. He re-emphasized the harm to archaeological sites from gas development.

5. **Adjoining private land to the Forest would be degraded by noise, dust, traffic, and declining property values due to gas development.**

Numerous individuals believed that the gas development on the Forest would negatively affect private land by decreasing property values and creating noise, dust, and traffic. Some felt that the effects of gas development on the Forest and upon their land are closely interrelated, and are disruptive, disconcerting, and destructive. They were concerned that any gas development on the Forest would result in disposal wells, flowlines, and compressor stations being located on nearby private land, with their associated disruptive effects, noise, and relatively permanent structures. Some were concerned about increased damage to private land from displaced deer and elk populations.

One individual thought that the tax burden of road maintenance and the destruction of the existing road system by large gas truck traffic would change the demographic makeup of La Plata County. Another suggested that the EIS examine the impacts of gas development on this relationship, including the displacement of people.

6. **Multiple use should be practiced on the Forest but disagreement exists over gas development as an appropriate use.**

Some commenters believed that gas development is an appropriate use of the Forest. These gas products, like any field crop, should be harvested. Since the HD Mountains are managed for multiple use and no unacceptable effects to any sensitive resource has occurred from past gas drilling activity, gas development should continue with appropriate and adequate mitigation. These commenters felt that gas development in the HD Mountains is compatible with the other resources there. In fact, the royalties from gas activity should help provide and maintain recreational facilities in the area, and help serve the public.

Other commenters believed that the Forest should not be managed for the economic gains of a few companies or individuals. They felt that this land should be managed for general public use, as a wilderness, or as a place for people to retreat and rejuvenate from the stresses of modern living. Commercial uses of the Forest, especially for gas development, are not appropriate. Some commenters urged that Forest uses must be for the greatest good and

benefit of the public, not any gas developers. The Forest would be devalued as a result of gas development.

Others felt that all resources, commodity and noncommodity, in the HD Mountains need to be considered equally. One resource should not be developed at the expense of any other. Others suggested that nonrenewable resources (e.g., gas) on public land should be saved until needed, since natural gas is not needed at this time. Still others questioned the loss and destruction of a 150-year-old ponderosa pine stand relative to the intangible benefits of a gas well pad. They believed that the economic return on the sale of these trees cannot be sufficient to cover those intangible benefits, while only minimally adding to our gas energy reserves.

7. **Coalbed methane gas should be developed on the Forest but only in an environmentally sensitive manner.**

   Some commenters believed that this area in Colorado would be actively developed for coalbed methane gas in the future and encouraged the development in a reasonable, environmentally sound manner. It is of vital national importance and necessity to reduce any future energy crisis. They stated that gas development is not inherently bad but needs to be done in an environmentally sensitive manner. One commenter wondered if coalbed methane gas development would be profitable without a federal tax credit.

8. **Coalbed methane gas development could contribute to the local, regional, and national economy, but caution should be exercised.**

   Some commenters believed this gas development would contribute to the economy, especially at the local level. They felt that the economic support to local communities, both direct and indirect, would be large and beneficial. Gas royalties supplement many local farmers and ranchers. Increased tax dollars due to gas development would be substantial.

   Other commenters believed that local communities should be cautiously optimistic. The tax windfall to counties from coalbed methane gas production would be contingent on future gas sales that only occur at the producer's financial convenience. They felt that the increased tax dollars are overtouted. Others stated that public land is an integral part of the local recreation

and tourist economy. They were concerned that gas development would negatively affect these economies. Some individuals expressed concern that energy development is a boom and bust situation which is not healthy or good for local economies.

9. **Gas development would negatively impact visual resources.**

Several individuals were concerned about the degradation or loss of visual resources and the natural appearance of the area from gas development. Roads and gas well pads are an eyesore in the HD Mountains and need to be hidden or camouflaged by fast-growing vegetation. One individual felt that the roads and gas pads in Sauls Creek have destroyed quality recreation and visual experiences for many people. Another commenter was concerned about the lost beauty of ponderosa pine stands in exchange for roads and gas well pads. They believe that the natural beauty of the Forest would be negatively altered by gas development. Other commenters stated that southwest Colorado is heavily dependent upon tourism and visuals. Gas well pads, flowline corridors, and excessive numbers of roads degrade and scar the visual landscape that tourists come to see. Some felt that the beauty and tranquility of the HD Mountains and the Pine River Valley must be maintained and preserved.

A commenter was concerned about the increased litter as a result of increased Forest access and use, and requested that it be addressed in the EIS.

10. **Coalbed methane gas development would negatively affect recreation in the HD Mountains.**

Several commenters expressed concern that the HD Mountains would be a less desirable place to recreate because of gas development. Two individuals felt that horseback riding, picnicking, camping, and generally escaping the stress of modern living have been destroyed by roads and gas pads in Sauls Creek. Noise pollution by pumpjacks and truck traffic has destroyed the quality recreational experiences of many people. One individual was concerned about the loss of field classroom in the Sauls Creek area for the Bayfield Biology classes due to gas development. Others expressed concern about the detrimental effects of gas development on the quality of hunting experiences. They believed that development in the HD Mountains would harm that segment of the economy dependent upon hunting. An individual suggested that the public would no longer use and recreate in a National Forest that is transformed into a natural gas field.

One commenter expressed concern about the increases in recreational use of the Forest on roads built for gas development. He requested that the possible side-effects of increased recreational use be evaluated in the EIS.

11. **Reduced public safety, increased damage and maintenance costs of roads, and road closures would result from gas development.**

Several commenters were concerned about increased wear and tear on Forest and county roads by large gas truck traffic and subsequent increases in maintenance. Two individuals considered that development would increase the danger and reduce the safety to the public from gas traffic on Forest and County roads, especially from those drivers violating safe and prudent driving speeds. One commenter indicated that she was nearly run off the Forest roads in Sauls Creek several times during well pad construction in the fall of 1988.

Others felt that travel management restrictions or closures would be needed to protect wildlife. Some commenters requested that the Spring Creek Road be closed to the public from December 26 to mid-April, and that the roads in Sauls Creek be closed to the public in two locations from mid-November to mid-April. They suggested that all new Forest roads be equipped with lockable gates. These roads should provide recreation and hunter access but should be closed to the public from mid-November to mid-April. An individual was concerned about misuse of privileged access to areas of the Forest by gas company employees and subcontractors. Another commenter expressed concern that flowline rights-of-way (ROW) not become uncontrolled roads.

12. **The quality of life of those residents near the Forest would be negatively affected by gas development.**

Several commenters stated that the quality of life would be negatively altered by gas development, especially for those residents near the HD Mountains. Two individuals felt that the quiet, country-life atmosphere of the HD Mountains has been damaged by noise, dust, and danger created by a steady barrage of gas traffic on Forest and County roads. Another commenter believed that the residents who live next to the HD Mountains have been raped and desecrated by gas development. They live there because of the isolation, quiet, and peaceful natural environment, with its relatively clean air and water. It is also a safe haven for

wildlife. Gas development would destroy this. Still another individual felt that quality of life is negatively impacted, e.g., fear of a visit from a gas company representative alerting them to gas development on their property or nearby NFS lands.

Some commenters requested that the FS preserve the HD Mountains for future generations. They would rather pay more per gallon of gas and other living expenses than look at gravel trucks and drill rigs and change the quality of their own and their children's lives.

13. **Casing and cementing procedures, and plugging and abandonment procedures for gas wells may not adequately protect the environment.**

Some commenters stated that the EIS should address the adequacy of the existing casing and cementing procedures for coalbed methane gas wells to protect potable ground water supplies. They insisted that gas well construction should be adequate to isolate the production zone and potential disposal zone to prevent gas and water flow between or into formations that are drinking water sources. Some commenters also discussed that the EIS examine the adequacy of existing plugging and abandonment procedures being utilized in protecting ground water sources for drinking water. The EIS analysis should determine if more specific plugging criteria should be stipulated for the HD Mountains. Another commenter felt that the EIS should evaluate the quality control of drilling and fracturing.

14. **Monitoring and administration of coalbed methane gas development and activities needs to be adequate to protect the environment.**

Some individuals stated that the EIS should describe a continual monitoring and inspection program of gas development activities, especially drilling, casing, cementing, and well operations, to ensure that the environment is protected. The EIS should examine the need for increased monitoring of drilling and production activities that could include more random inspections. The monitoring and inspection program should be designed to meet appropriate environmental and health laws and regulations.

One commenter requested that the EIS evaluate the need for specific ground water monitoring requirements for onsite drilling and produced water reserve pits, and display specific criteria which would trigger the specific monitoring requirements. Others asked that the EIS consider

the need for an active monitoring program of potable ground water levels and volumes in coalbed methane gas development areas. Another stated the need for an air quality monitoring program that evaluates areas downwind of gas development activities.

One individual believed that a ground surface archaeological survey of cultural resources would not adequately protect those resources, especially subsurface archaeological sites and ruins. He described no solution to the problem other than to allow no gas development.

Another commenter requested that the EIS develop a process to allow citizens to report any suspected gas development deficiency on the Forest. This would help in the administration and monitoring of gas development activities.

15. Gas development and activity would degrade air quality in the area.

Numerous commenters were concerned about the effects of coalbed methane gas development and activity on clean air. Their concerns were directed primarily at dust. However, some were concerned about any air pollution impacts to the pristine air of the local Class 1 Air Quality Area, especially from internal combustion engines on wastewater disposal structures and from truck activity associated with well maintenance. One person wondered about the effects of gas well flaring on air quality.

16. Gas development and activity would increase noise levels in their respective areas.

Numerous individuals were concerned about increased noise levels due to gas development and activity. Some are disturbed by the noise from pumpjacks, gas truck traffic, and compressor stations. Some are annoyed by the lack of quiet in some areas of the HD Mountains. Where the Forest has been developed for coalbed methane gas (i.e., Sauls Creek), people are unable to enjoy the quiet. They feel that the quality of their recreational experiences would be further destroyed by noise from pumpjacks and gas traffic.

17. The wilderness classification and roadless qualities of the HD Mountains should be evaluated in the EIS.

Some commenters stated that although the HD Mountains have all the qualities for wilderness areas and were proposed as wilderness areas in the past, the designation failed because of a road to a gas well pad. They suggested that some portions of the HD Mountains should be considered again as wilderness areas, excluding those areas destroyed by gas development.

One individual felt that the nature and quality of the HD Mountains cannot be enjoyed without running into multitudes of people who access all the new roads. He believes that the HD Mountains are overrun with roads as a result of coalbed methane gas development.

18. **Coalbed methane gas development would negatively affect soils and increase soil erosion.**

Some commenters were concerned about the release of drilling fluids, fuel oils, and produced water into and onto soils. They requested that a containment strategy be developed as a part of mitigation for contaminated soils in the EIS. Some are also concerned about soil erosion in general from gas development.

19. **Coalbed methane gas development in the HD Mountains should halt while the EIS is being prepared.**

Some commenters stated that the two Environmental Assessments (EAs) to be prepared for Amoco's 1989 proposal of six gas wells are inappropriate and illegal since this EIS is being concurrently prepared. They felt that coalbed methane gas development should stop on the Forest until the EIS is finished. Other commenters, generally the Sierra Club Legal Defense Fund (SCLDF), argued that the FS will violate NEPA if these two EAs are completed prior to the final EIS. The SCLDF framed this issue by presenting four arguments to support their position. Their arguments for no further drilling activity were as follows:

1. They described these gas well projects as major federal actions that would significantly affect the human environment. Two recent court decisions that require a broad-based or field wide EIS, <u>Park County Resource Council v. USDA</u>, 817 F 2d 609, 624 n.5 (9th Cir., 1987) and <u>Michael Gold, et. al.</u> 180 IBLA 231 (April 24, 1989), were cited as precedent for developing an EIS for these projects rather than an EA. No more drilling should occur until the cumulative effects for the entire HD Mountains from reasonable and foreseeable coalbed methane gas development is known.

2. The second argument was that these projects are connected with the large scale, coalbed methane gas development of the HD Mountains which is being analyzed in this EIS and cannot stand alone from an environmental analysis standpoint. The two court decisions were again presented in support of this position.

3. Thirdly, they argued that is it unlawful to allow any more gas development until the programmatic EIS is completed; otherwise, the HD Mountains EIS would be compromised.

4. The fourth argument was that effects of coalbed methane gas development on the human environment are highly controversial and subject to substantial disputes. Thus, under NEPA, an EIS would be required rather than the EAs. Cited as controversial are the effects of disposal water on local drinking water wells, impacts of truck traffic on roads, wildlife, and water supplies, and effects of road and well pad construction on archaeological sites and ruins. The commenters stated that the cumulative effects of coalbed methane gas development cannot be adequately assessed in the EA's.

20. Inadequate scoping has occurred for this EIS.

Some individuals indicated that public scoping of the issues and concerns that should be addressed in this EIS have been too general, too short, and not rigorous enough. They cited a very short public notice for the first public scoping meeting. Some requested that scoping be continued throughout the EIS process and that substantial public involvement be sought. One individual wondered whether the FS could provide a couple of newsletters or newspaper articles before the EIS is made available.

21. The EIS timetable as described in May and June, 1989 was inadequate to obtain the information needed.

Commenters questioned the EIS timetable that was described during the May and June, 1989 public meetings. They felt that the time frames were insufficient to obtain adequate quality information for the EIS.

22. Wastewater disposal, gas development other than coalbed methane, and total field development should be studied in the EIS.

Some individuals asked that the wastewater disposal infrastructure (i.e., disposal wells and collection systems) associated with coalbed methane gas development be studied in the EIS. Others requested that oil and gas development other than coalbed methane be evaluated in the EIS. Commenters stated that the EIS needs to display the total gas development of the HD Mountains. This issue is related to the issue of changing well spacing guidelines and displaying a worst-case scenario.

23. The scope of this EIS is too narrow and needs to be expanded to be a "people's" EIS.

One commenter believed that the scope of this EIS was too narrow and not sufficiently rigorous. It needs to be a "people's"EIS, an EIS that addresses community concerns and the human element. Instead of only studying what the noise levels would be, the EIS needs to display who would hear that noise and what the impacts would be to those people. Instead of only describing how many jobs this gas development would bring to the area, the EIS needs to display what kind of jobs gas development would bring. The commenter felt that interviews should be conducted with private landowners adjacent to the Forest for the EIS.

24. The decision on gas development has already been made before the EIS is finished.

One individual wondered if the FS and BLM have already made a decision regarding drilling activity in the HD Mountains for 1990 and beyond, before completion of the EIS.

25. The public is denied access to some data or records for the EIS.

One commenter questioned why the public does not have access to all the data and records used for the development of the EIS.

26. The FS and BLM need to provide a meaningful appeal period for this EIS and grant a stay of any activity.

One commenter stated that any potential appellants need a reasonable period of time to review the EIS and accompanying decision documents. Prior to December, 1988, appeal efforts have been dismissed as moot since gas wells were drilled so fast that no one had an

opportunity to seek and obtain an administrative stay. They believe that a stay is appropriate for the following several reasons:

- The potential protestants live and recreate in the HD Mountains and are interested in protecting this area and its associated natural resources.

- A stay is needed to ensure a meaningful appeal period. Otherwise, the appellants would be frustrated and unable to effectively voice their concerns.

- Without a stay, irreversible, immediate, and severe site-specific impacts would occur to the landscape, vegetation, noise, safety, erosion, recreation, wildlife, surface water quality, cultural resources, ground water, and the surrounding local communities.

- There would be no substantial harm to the environment, the proponent, or the potential appellants from granting the administrative stay.

27. The cumulative effects of gas development on all resources of the HD Mountains should be evaluated in the EIS.

Several commenters requested that the EIS examine the individual and cumulative effects of coalbed methane gas development on all the resources of the HD Mountains and summarize them. The cumulative effects should include all reasonably foreseeable gas development actions both on and immediately off the Forest. One individual suggested that the cumulative analysis include all reasonably foreseeable gas activity and other Forest management activities (such as logging, recreation, etc.) over the next 25 to 50 years.

These commenters noted that effects from individual wells may seem insignificant but from a cumulative standpoint, they are very significant. Prior to December, 1988, gas development on the Forest and adjoining private land was looked at in a piecemeal approach. They insisted that a cumulative impact analysis address all gas development effects on all the resources of the HD Mountains, especially focusing on concurrent operations. A commenter wondered what the extent of the cumulative effects would be off the Forest, particularly for disposal wells.

28. **This EIS should be expanded to evaluate the effects of gas development on the San Juan Basin.**

Several commenters requested that the scope of this EIS be expanded to cover the entire San Juan Basin. They cited a letter from Congressman Ben Nighthorse Campbell which asked the FS to conduct such a study with the HD Mountains EIS. They felt that there is a need for a single, broad-based analysis of environmental and social effects for the regional area. The HD Mountains EIS does not cover a sufficiently large area. A San Juan Basin-wide EIS could address this new coalbed methane gas technology with its new associated problems. Without it, they believe that issues such as ground water contamination, truck traffic complaints, and concerns of long-term effects from gas development in the Basin would not be addressed and the public would not be allowed to comment. Since the driving force behind coalbed methane gas development is a federal tax incentive, a federal agency such as the FS needs to conduct the basin-wide study. Also, because the FS is preparing the HD Mountains EIS, a basin-wide study that is included in this ongoing EIS would eliminate duplication of environmental analyses by other agencies.

29. **The current Forest Plan inadequately addresses coalbed methane gas development and the concentration of gas activity on the Forest, and needs to be amended.**

Several individuals commented that the Forest Plan inadequately addressed coalbed methane gas technology and its potential environmental effects. It should be amended. In their view, this new gas development is unique and is, therefore, different from traditional oil and gas development. They believed that impacts from year-round pumping and handling of large amounts of produced water, as well as dangers from explosions, leaking flowlines, or subsequent forest fires, were not addressed in the Forest Plan's EIS. The increased levels of noise and general environmental disturbance are far beyond what was contemplated in the Forest Plan. Furthermore, the Forest Plan needs to be amended and updated to reflect the added FS responsibilities described under the Leasing Reform Act and under the COGCC rules and regulations on ground water protection and coalbed methane wastewater disposal.

Several commenters stated that most of the recent oil and gas development (i.e., prior to 1989) has not been distributed Forest-wide as projected in the Forest Plan's EIS, but has been concentrated on 5 percent of the Forest in the HD Mountains. They interpret the Forest Plan

as analyzing extensive development scenarios (i.e., development spread across the Forest rather than concentrated in time and space). Therefore, if the Forest Plan's EIS does not address the concentrated development scenario, the Forest Plan must be amended to address new rates of development, concentration of development, and technologies not previously addressed in the Forest Plan's EIS. One commenter asked that the Forest Plan be amended to explain the differences between cumulative effects of coalbed methane gas development and conventional gas development. Another individual wondered how the HD Mountains EIS would affect the "trigger mechanism" in the Forest Plan's EIS relating to an average of 9 wells per year.

One commenter disagreed with the previous commenters on this issue and believed that the technical drilling procedures for coalbed methane gas are the same as for conventional oil and gas activities. Since the level and type of mitigation utilized is also the same, environmentally sensitive resources would continue to be adequately protected and did not call for any amendment of the Forest Plan.

30. **Appropriate mitigation, including reclamation and facilities planning, was suggested and should be considered in the EIS.**

Numerous commenters suggested various mitigation measures and standards that should be considered in the EIS. They are:

a. Utilize setbacks, paint equipment to blend with the surroundings, avoid "skylining" of permanent equipment and landscaping, and keep flowlines in previously developed areas to mitigate any adverse visual impacts. Plant hedges, locally indigenous trees, and/or fast growing trees (e.g., green ashes) close together to visually hide or camouflage well pads from any public roads.

b. Close all roads in deer and elk winter range areas from mid-November to mid-April. Install lockable gates on every new road. Minimize gas maintenance activity in winter and/or restrict these activities as much as possible in mid-day hours during the winter months to minimize big game stress and harassment. When roads and well pads are reclaimed, plantings should be geared towards wildlife habitat improvement, including turkeys and other non-big-game species. Utilize the wildlife mitigation measures specified by the BLM's Farmington, New Mexico office in their recent environmental analysis.

c. Do not permit gas development if the effects to recreation and wildlife cannot be mitigated. Other areas on the Forest with a timber or grazing emphasis should be changed to a wildlife and recreation emphasis to compensate the public for losses to wildlife and recreation from gas development.

d. Plan the treatment of wastewater and its disposal from a Forest standpoint, with a goal of integrating new wells and flowlines into one or more primary systems. Trucking of produced water should be prohibited on the Forest. Water collection systems should be designed and installed as early as possible. Place companion water flowlines in the same trench as the gas collection line. Ensure that flowline ROWs do not turn into roads.

e. Replace or improve wildlife habitat when total acreage losses reach an identified level. Automation of gas wells should be emphasized and/or required in critical wildlife habitat areas. Related gas activity should only be allowed during certain periods of the year and hours of the day.

f. Utilize adequate and appropriate water and air quality protection standards. The FS should consider adopting the La Plata County standards in the areas of noise and visual mitigation. Meet the appropriate wastewater treatment standards, provide standards for onsite littering and provisions for cleanup, and minimize any occupational and public health hazards.

g. Dispose of produced water at disposal wells in excess of 5,000 feet below the ground surface (i.e., below the Fruitland Formation).

h. Develop provisions for removal of equipment and reclamation of well pads and roads. Identify a containment strategy to deal with any contaminated soils. Determine if more specific well plugging criteria should be stipulated for the HD Mountains to protect the environment.

i. Utilize the most up-to-date noise abatement of pumpjacks and compression stations.

j. Monitor the potable ground water levels and volumes in coalbed methane gas development area. Monitor the quality and quantity of drinking water in water wells of private landowners surrounding the Forest. Monitor the air quality of areas downwind from coalbed methane gas development areas.

k. Develop a process to allow citizens to report any suspected gas development deficiency on the Forest.

31. Federal lease terms and rules negatively affect adjoining private land.

One individual felt that there is more accountability, quality control, and environmental protection standards in federal leases than in private or state leases. A case in point is disposal of produced water. Generally, disposal of produced water is allowed at shallower depths and higher pressure on private land than on federal property. The individual insisted that until all leases are regulated similarly by both state and federal agencies, no produced water should leave federal land. It should instead be disposed of on federal land. The FS should not contribute to the environmental damage of private property by ignoring or condoning inadequate state regulation of produced water that is generated on federal land but disposed of on private property.

This commenter requested that the pooling of leases on federal land and adjacent private land be addressed in the EIS. By pooling, adjacent private landowners could be forced to receive disposal wells to handle produced water from gas wells on federal land.

32. Gas development and activity would increase the potential for wildfire, explosions, and leaks from flowlines.

Some commenters expressed concern that coalbed methane gas development would increase fire hazards and danger and lead to increased wildfire potential on the Forest and on adjacent private forested land. They were also concerned about the increased threat of explosions and leaking gas or water flowlines.

33. Illegal activities on the Forest would increase as a result of increased access for gas development.

Several individuals were concerned about increased poaching of wildlife, especially deer and elk, and increased pot hunting of archaeological resources due to more Forest access as a result of coalbed methane gas development. One commenter was concerned about the misuse of privileged access to areas of the Forest by gas company employees or subcontractors.

34. **Gas development may threaten State listed plant species.**

An individual expressed concern about the effects of coalbed methane gas development and activity on any state-listed flora species in the HD Mountains.

35. **The various disposal alternatives or handling techniques of produced water from coalbed methane wells need to be explored in the EIS.**

Some commenters requested that this environmental analysis should comprehensively examine several produced water and work-over fluid disposal alternatives, such an underground disposal, evaporation, and surface discharge. In addition to the environmental effects, economics and cost effectiveness of these various alternatives need to be addressed. The analysis of disposal alternatives for exploration wastes should look at offsite, onsite, and underground disposal. The analyses should evaluate the need for specific ground water monitoring requirements for onsite drilling and produced water reserve pits, as well as specific criteria which would trigger the specific monitoring requirements.

One commenter asked that the EIS examine alternatives that make potable water from produced water. This water could then be used for livestock or wildlife watering.

Another individual requested that the EIS study wastewater disposal from a Forest or area standpoint, with the goal of integrating new gas wells and disposal flowlines into one or more primary systems.

36. **Future gas well spacing guidelines may be changed and the effects of any reasonably foreseeable well spacing on the resources of the HD Mountains should be studied in the EIS.**

For coalbed methane gas development, the current well spacing requirements from the COGCC is two wells per 640-acre section. Two commenters urged that the EIS address a worst-case scenario of at least four wells per section as the BLM's Farmington, New Mexico office did in their environmental analysis. The commenters stated that the COGCC could change the well spacing requirements as they did in Weld County, Colorado. They also indicated that analysis of the current well spacing of two wells per section is not enough for a worst-case scenario.

37. Standardized guidelines and coordination of all federal, state, and local agencies for oil and gas development across all political boundaries were requested.

Several individuals requested that all federal, state, and local agencies coordinate and develop standardized guidelines for oil and gas development across all political boundaries for environmental protection reasons. This was especially requested for issues such as handling and disposal of produced water. This issue was related to the issue that called for a San Juan Basin-wide EIS to study the effects of coalbed methane gas development.

38. Monitoring of domestic water wells adjacent to the Forest should be included as mitigation in the approved EIS.

Some commenters asked that monitoring of private drinking water wells near the Forest be included as mitigation for gas development in the EIS. An individual wondered if the private landowner is solely responsible for testing the water quality or quantity of their own drinking water well. Tied to this specific issue are issues on adequate monitoring and appropriate mitigation.

39. Alternative techniques for coalbed methane gas development should be examined in the EIS.

An individual suggested that alternative drilling techniques for coalbed methane gas development be considered in the EIS. For example, horizontal or directional drilling should be evaluated. Directional drilling could possibly eliminate the need for so many vertically drilled gas wells.

40. Possible indirect effects of coalbed methane gas development on human health should be identified in the EIS.

An individual asked that the EIS examine the potential indirect effects of gas development on human health and specifically requested that radon be studied. He wondered if gas development increases the release of radon to the terrestrial environment or stimulates its movement in subsurface formations.

1.7 OPPORTUNITIES

Opportunities that may be derived from the drilling proposal include:

1. The drilling proposal would provide Amoco the opportunity to develop coalbed methane gas wells with fill in areas that are partially developed and further develop other wells.

2. The potential exists for improving existing FS transportation system roads within the Study Area through improved maintenance and additional surfacing, or through providing new system roads for use in future land management projects.

3. The drilling proposal and related support activities may provide economic benefit to nearby communities.

2.1 INTRODUCTION

Detailed descriptions of each of the three alternatives are presented in this chapter. The No Action Alternative will be referred to as Alternative A, the Proposed Action Alternative as Alternative B, and the Current Direction Alternative as Alternative C.

Amoco Production Company (Amoco) has filed Applications for Permit to Drill (APDs) with the Bureau of Land Management (BLM) to drill five coalbed methane gas development wells on National Forest System (NFS) land in the Sauls Creek drainage. Proposed locations of each well are as follows:

- Federal 4-1 - SE 1/4 NW 1/4 of Section 4, T34N, R6W
- Federal 5-1 - SW 1/4 SE 1/4 of Section 5, T34N, R6W
- Federal 8-1 - NW 1/4 NW 1/4 of Section 8, T34N, R6W
- Federal 28-1 - SW 1/4 SE 1/4 of Section 28, T35N, R6W
- Sauls Creek B-1 - NE 1/4 NW 1/4 of Section 27, T35N, R6W

In addition to these five applications, Amoco has submitted a plan of field development for the drilling of 29 additional coalbed methane gas wells; construction of additional facilities including access roads, water, and gas flowlines; and construction of a compressor station within the HD Mountains Study Area. Twenty-eight wells, including the five wells for which APDs have been submitted, are proposed by Amoco for drilling on NFS lands in 1991. Six wells are proposed by Amoco for drilling on adjacent private land. These proposed actions form the basis for Alternative B (Figure 2-2 in Subsection 2.3).

The Colorado Oil and Gas Conservation Commission (COGCC) has established well spacing requirements for coalbed methane gas production of one well per 320 acres (two wells per section) (COGCC Order 112-60). The 320-acre parcels known as units consist of the N 1/2 and S 1/2 or the E 1/2 and W 1/2 of a full section. The purpose of equal spacing is to ensure optimum drainage and recovery of the natural gas resource within a field development. All proposed wells would be located in the northwest and/or southeast quarters of sections and within the units and spacing areas of opportunity known as "windows," as prescribed by the COGCC. The "windows" are approximately 40 acres in size, with some being smaller and some larger depending on the size

and dimensions of the section. Size and dimensions of "windows" are dictated by the specific distances of setback from section lines established by the COGCC. Finding Number 6 of COGCC Order 112-60 specifies a well can be located no closer than 990 feet to any outer boundary of an unit, nor closer than 130 feet to any interior quarter section line. A coalbed methane gas well can be located anywhere within a "window" under COGCC Order 112-61, should no other well citing constraints apply.

Following a field review of the five well locations for which APDs had been received, and an evaluation of probable locations of the additional 23 wells to be located on NFS land, an interdisciplinary team determined that an Environmental Impact Statement (EIS) would be required. The Forest Service (FS) and BLM concluded that the Amoco proposals for field development in the HD Mountains Coalbed Methane Gas Study Area may significantly affect the human environment.

The 28 wells proposed for construction in 1991 would not be the first wells to be permitted and drilled on NFS land in the HD Mountains Study Area. Twenty-one coalbed methane wells and five conventional technology wells (four have been abandoned) have already been drilled, access roads have been constructed, and some water and gas flowlines have been installed. However, the installation of several flowlines remains to complete the combined access road/flowlines network to allow production from all the existing coalbed methane wells. Reclamation and revegetation of the installed flowlines portion of the 50-foot wide access road/flowlines right-of-way (ROW) remains to be completed for the existing wells on NFS land in the Sauls Creek area. It is the effects of these existing facilities, as well as the probable construction of additional flowlines to complete the gathering network for the existing wells, that will be assessed in the required Alternative A. The 28 additional wells proposed by Amoco for drilling on NFS land would not be permitted under this alternative.

In response to a public issue regarding a need to study the effects of a range of field development scenarios, a full field development plan has been prepared and is presented as Alternative C. This alternative provides for the assessment of effects of well field development should all available and technically feasible drilling spaces or windows be occupied by a well within the Study Area. With full implementation, this alternative would involve the drilling and operation of 95 new wells and ancillary facilities on NFS land, one well on State land, and 20 wells on private land within the HD Mountains Study Area. The 28 wells on NFS land and the six wells on private land for Amoco's Alternative B are included in the totals for this alternative. This alternative constitutes Alternative C.

For Alternatives B and C, the 50-foot wide road and flowline ROW, displayed on Figures 2-2 and 2-7, is centered on a 600-foot wide corridor system. Possible lateral relocation of the transportation ROW can occur up to 275 feet off the proposed center line during final staking. This corridor was developed to minimize or avoid resource impacts, especially to cultural, wildlife, visual, soil, and water resources. Impacts on resources were also assessed for the corridor and are presented in Environmental Consequences, Section 4.0.

2.2 ALTERNATIVE A - NO ACTION ALTERNATIVE

National Environmental Policy Act (NEPA) procedural regulations require federal agencies to evaluate in detail an alternative to a proposed action of No Action, and to use the No Action Alternative as a baseline for comparing and measuring the effects of the other alternatives in which some action is proposed (40 CFR 1502.14(d), Forest Service Handbook 1909.15, 23.1). Alternative A - No Action would not consider approval of Amoco's APDs for wells on NFS lands, but would provide for comparison of effects to the other alternatives.

This alternative includes the completion of flowline connections to existing wells. Approximately 25.5 miles of gas and water flowlines placed in the 20-foot-wide pipeline right-of-way (ROW) are likely to be constructed adjacent to existing roads (Figure 2-1). An estimated 19 miles of the flowline ROW would be located on NFS land; the remaining 6.5 miles of flowline ROW would be located on private land. Route deviations from the existing access road would result from routing to minimize disturbance. These proposed flowlines would be constructed, operated, and maintained in conformance with requirements/stipulations presented in the Plan of Operations as attached to Special Use Permits. An example Plan of Operations for constructing, maintaining, and operating a flowline on the San Juan National Forest is presented in Appendix A-1.

Twenty-one coalbed methane gas wells and five conventional gas wells (four have been abandoned) have been drilled on NFS land in the HD Mountains Study Area. Well names, locations, and acreages of long-term residual disturbance are presented in Table 2-1. Mapped locations of these well sites are identified in Figure 2-1. Short-term residual disturbance acreages on NFS lands in the form of 6 miles of unrevegetated 20-foot wide flowline ROW in the Sauls Creek area total 15 acres. Reclaimed and revegetated surfaces of previously disturbed areas associated with (1) cuts and fills along access roads and adjacent to well pads, and (2) flowline construction ROWs, are not included in these tabulations.

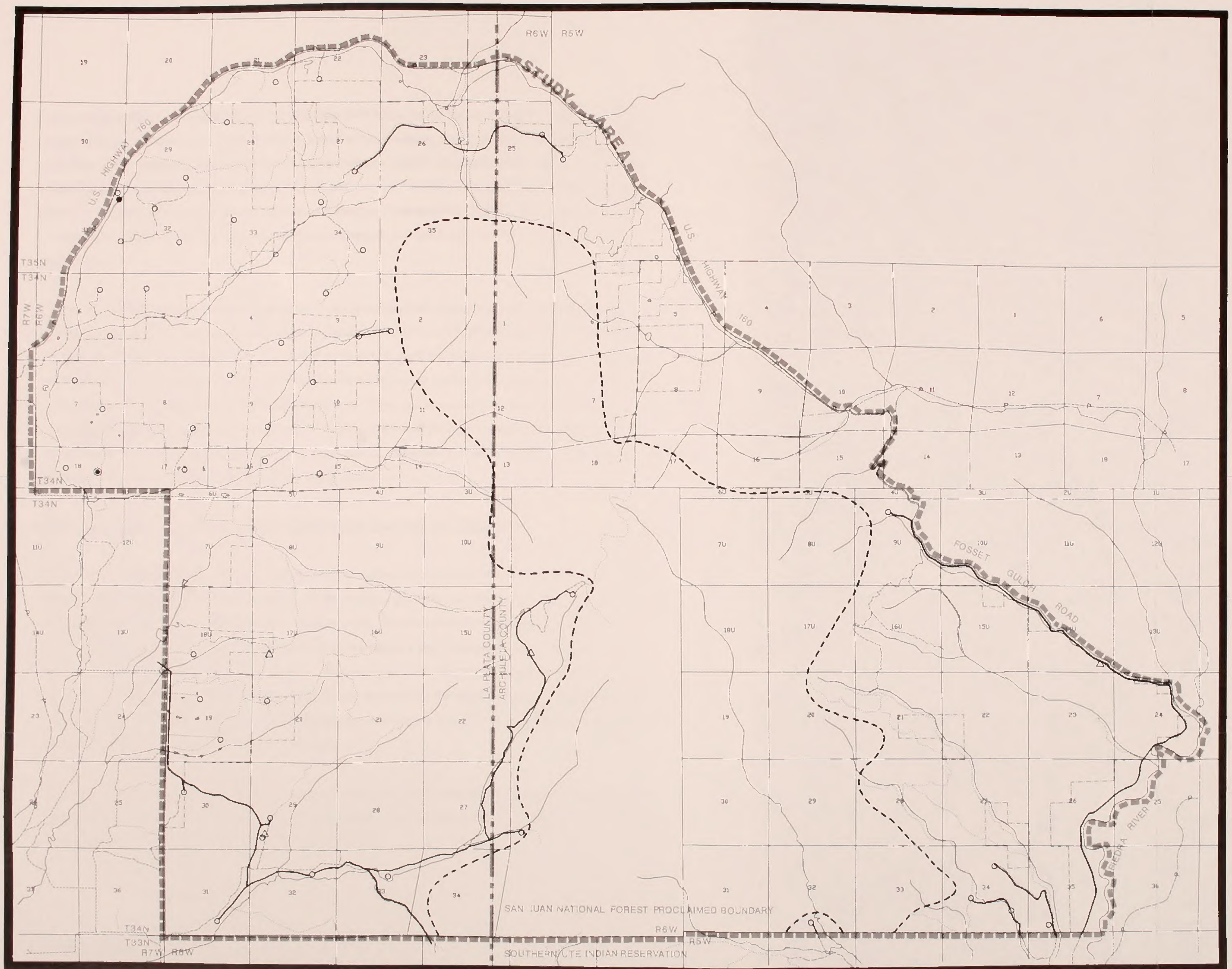
TABLE 2-1

NAMES, LOCATIONS, AND ACREAGES OF LONG-TERM DISTURBANCE OF THE 21 EXISTING WELL LOCATIONS[1] ON NFS LANDS WITHIN THE STUDY AREA

Coalbed Methane Well Name	Location		Acreage[2]
Sauls Creek No. 1	NW 1/4 NW 1/4 Sec. 34	T35N, R6W	2.3
Sauls Creek No. 2	Center SE 1/4 Sec. 34	T35N, R6W	2.9
Sauls Creek No. 3	SW 1/4 SE 1/4 Sec. 27	T35N, R6W	1.6
Fisher-Mark Federal A-1	NW 1/4 NW 1/4 Sec. 9	T34N, R6W	1.9
Fisher-Mark Federal B-1	SE 1/4 SE 1/4 Sec. 4	T34N, R6W	1.3
Fisher-Mark Federal B-2	NE 1/4 NW 1/4 Sec. 3	T34N, R6W	2.4
Federal 2L-1	NW 1/4 SW 1/4 Sec. 2	T34N, R6W	2.4
Federal 25A-1	SE 1/4 NE 1/4 Sec. 25	T35N, R6W	2.2
USA Amoco Com AC-1	NW 1/4 SW 1/4 Sec. 30	T35N, R5W	2.1
Federal 9U-1	NE 1/4 NW 1/4 Sec. 9U	T34N, R5W	3.5
Pine River 2-29 and Spring Creek 2-29 (Conventional)	NW 1/4 SW 1/4 Sec. 29	T34N, R6W	1.9
Pine River 3-31	SW 1/4 SE 1/4 Sec. 31	T34N, R6W	1.0
Pine River 4-32	SE 1/4 NE 1/4 Sec. 32	T34N, R6W	2.1
Federal 33L-1	SW 1/4 NE 1/4 Sec. 33	T34N, R6W	1.2
Federal No. 26	SE 1/4 SW 1/4 Sec. 26	T34N, R6W	2.0
Pargin Mountain No. 2	NW 1/4 NE 1/4 Sec. 14U	T34N, R6W	3.3
Pargin Mountain No. 3	SW 1/4 SE 1/4 Sec. 32	T34N, R5W	2.0
Pargin Mountain No. 9	NE 1/4 SE 1/4 Sec. 34	T34N, R5W	2.5
Pargin Mountain No. 10	NW 1/4 NE 1/4 Sec. 34	T34N, R5W	2.4
Pargin Mountain No. 11	NE 1/4 SW 1/4 Sec. 34	T34N, R5W	2.4
Bull Creek Federal	S 1/2 SW 1/4 Sec. 35	T34N, R5W	1.9
			45.3

[1] 21 coalbed methane gas wells and 1 conventional gas well; Pine River 2-29 and Spring Creek 2-29 are located on the same well pad.

[2] Acres of residual disturbance includes well pad acreages and access road acreages where appropriate.



ALTERNATIVE A-NO ACTION

- ○ EXISTING WELL SITE
- ● DISPOSAL WELL SITE
- ◉ COMPRESSOR AND DISPOSAL WELL SITE
- △ ABANDONED WELL SITE
- PROPOSED PIPELINE
- ROADS (PAVED, GRAVEL, AND DIRT)
- NATIONAL FOREST SYSTEM BOUNDARY
- UNROADED AREA BOUNDARY

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

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FIGURE 2-1

In addition to the 21 wells which have been drilled on NFS lands, 20 coalbed methane wells and two produced water disposal wells have been drilled on private land within the Study Area. Based on an evaluation of areas of disturbance associated with wellsites and transportation corridors on private land, use of three acres of disturbance per wellsite and 0.75 miles of 20-foot wide access road results in a conservative estimate of 111 acres of remaining disturbance for the 22 wells and associated transportation ROWs. An electrically powered compressor station is located on the produced water disposal well pad located in Section 18, T34N, R6W on private land.

Given the existing areas of disturbance associated with recent coalbed methane gas development and previous conventional gas development activities, remaining areas of disturbance on NFS land correspond principally to the gravel and dirt roads that were developed to meet the need for access under approved multiple use requirements. There are approximately 33 miles of gravel, all-season road on NFS lands, which equates to 80 acres of surface disturbance for a road width of 20 feet. There are approximately 38 miles of additional dirt road on NFS land, which equates to 55 acres of surface disturbance for an average road width of 12 feet. Approximately 23 miles or 56 acres of gravel road, and 22 miles or 32 acres of dirt road (total acreage is 88 acres), are located off NFS land within the Study Area.

2.2.1 Description of Specific Construction Measures and Operations for Flowlines

As part of standard practice, dual flowlines collection systems are installed for the production of coalbed methane wells. One collection system transports the methane gas from the wells to a central location where it is compressed for further transportation to the sales point. The second collection system is used to transport the produced water that occurs with the production of the methane gas. The produced water is collected at a central point (not necessarily the same point as the gas) where it is boosted in pressure and injected into subsurface formations. All water disposal facilities are approved by the COGCC and/or the Environmental Protection Agency (EPA). Both collection and gathering systems are designed so that they are routed in the same flowline ROW and in the same flowline trench.

If the anticipated water production rates are very low, then typically the flowlines collection system cannot be economically justified. In this case, water is produced into wellsite tanks for temporary storage and subsequently trucked off site to an approved disposal facility.

The remainder of this section presents Amoco's standard methods of operation for the design and construction of flowlines. The design and construction of the flowlines, which make up the gathering system, begins with a preliminary route selection through the affected area. In the case of NFS land, route selection tends to follow the existing road system that is in place. Where possible and practical, the flowline routes will parallel the roads that run nearest the wells to be connected. Preliminary route selection is verified by the FS. Once there is agreement between the proponent and the FS on the route surveyed, the route is surveyed for distances involved, for all terrain data, and for bends and deviations from the roadway. Upon completion of the survey, the data are forwarded to design engineers who then take the data and create a drawing called an alignment sheet. The alignment sheet contains all the relevant information necessary to instruct a contractor on how the flowlines are to be routed, how they are to be installed in the ditch, and where the contractor has to install special equipment. The alignment sheets will also allow the proponent to do a material estimate of what items are required to construct the flowlines.

Once the alignment sheets are complete and the materials ordered, the proponent prepares a bid document describing to the prospective contractors how the flowlines are to be constructed. The bid document contains a listing of all the restrictions imposed by the FS and any additional restrictions to be imposed upon the contractor. Amoco requests that all prospective bidders attend a job showing. At the job showing, all restrictions are again reviewed by Amoco with the bidders. Clarifications are stated and then a site visit is conducted. At the site visit, Amoco's Construction Supervisor will review the entire route of the flowline and outline any of the special restrictions that are going to be imposed during the construction process.

All contracts for flowline construction are awarded on the basis of competitive bid, and Amoco selects the contractors' abilities that best match the construction difficulty.

Before construction begins, the flowlines routes are staked indicating to the contractor the center line of the trench that is to be excavated. In addition, the survey stakes mark the outer limits of the flowlines ROW. The survey conveys to the contractor the extent of the working land that he is allowed to use for the purpose of construction.

After the award of contract, the contractor begins to mobilize his operation. The contractor will establish a central base from which to direct all work, and will also arrange for all the specialized equipment needed for construction of the flowlines.

The first task to be undertaken by the contractor is to clear the ROW of major obstacles that will impede construction. Such work will entail clearing brush by hand or by a mechanized mower called a brush hog. Trees that have been identified for removal are cut and stacked along the ROW. All trees are limbed and the brush is laid alongside the ROW for cleanup after construction. Trees cut of commercial size are sold by the FS. Neither the contractor nor his employees are allowed to remove any of the wood from the ROW unless authorized by the FS. Once clearing is complete, all survey stakes are replaced to their original location.

After clearing the ROW of major obstacles, the contractor will start a track dozer along the ROW to level out any changes in sharp elevations. Flowlines require a gradually sloping ditch bottom and by making these elevation cuts ahead of time, the contractor eases the installation process. Note, however, that the contractor is required to restore the surface ground contours as close to the original as possible.

With the ROW contouring complete, the contractor will start the excavation of the flowlines trench. To excavate the trench, the contractor may use either track mounted backhoes or a wheel trencher depending upon the terrain being crossed. The excavated dirt from the trench is piled alongside the trench. The trench depth is dictated by the size of the pipes that are to be installed. For coalbed gas gathering flowlines, the top of the pipe as it lies on the trench bottom must have a minimum 4.5 feet of cover.

The width of the trench is a function of the size of the lines being installed. The trench requirements established by Amoco are that 6 inches of space must exist between the flowline outer wall and the trench wall, and that there must be 10 inches of space between the flowlines as they lie in the ditch (edge to edge).

When sufficient trench has been excavated, the contractor will then arrange for flowline materials to be delivered to the ROW. If the flowline to be installed is steel, wooden cribbing are strung along the route and are used to support the pipe as it arrives. The pipe is strung along the ditch route and positioned for the next phase of construction. If the flowline to be constructed is fiberglass, the pipe is bundled and delivered on pallets. If polyethylene pipe is used, 1,000-foot rolls are delivered to the site. In all cases, the contractor will establish areas where materials are to be delivered. In addition to the pipe, fittings used to connect or join the pipe are delivered as required to the ROW. During this phase of construction, many vehicles travel the ROW carrying out various aspects of the construction process.

Steel pipelines are joined by the process of welding. The welding equipment is located on trucks either 3/4 ton or 1 ton in size. There may be anywhere from one to five welders working on the job, depending on the

distance involved and the time constraints imposed. Typical construction practice calls for the contractor to start at one end of the pipeline and progress in an orderly fashion to the other end. However, there are occasions when the contractor is required to skip around a location and then return to complete that portion of the system. Should any field bending of the pipe be required in order to fit the contour or route of the trench, the sideboom tractors equipped with bending shoes are utilized.

After welding, a representative number of joints are radiographed by x-ray to ensure that the weld meets the standards established by Amoco in the construction requirements. Amoco inspectors, along with the x-ray company representatives, review the x-ray films and perform the interpretation (note that the x-ray company is hired by Amoco). The welded steel joints of pipe are x-rayed on a statistical basis to ensure that every welder is inspected, that a representative sampling of welds are x-rayed, and that mechanical integrity of the joint is maintained. After the joint has passed inspection, it is wrapped with a protective tape, as is the balance of pipe prior to installation. Often, steel pipe is purchased with an external coating to reduce the cost of protective tape.

When a sufficient length of pipe has been assembled, the contractor will begin to lower the pipe into the trench. Prior to lowering, the trench bottom is inspected by Amoco to ensure that the conditions will not damage the protective coating on the pipe. If ground conditions dictate, excavated soil or imported sand padding will be placed in the trench, before the pipe, so that the pipe rests on a cushioned surface. Through the use of sideboom track vehicles (usually 2 to 3 units), the pipe is picked from the wooden supports and placed on the bottom of the trench. Once the pipe is in the trench, the padding is completed by placing soil/sand over and around the pipe to a depth of 6 inches. Soil padding materials must be free of rocks. Sand padding material would be obtained off site from a private sand and gravel pit, located off NFS lands, and trucked to the trench. With padding complete, backfilling of the trench takes place using the material that had been previously excavated.

Fiberglass pipe, used on both gas and water gathering lines, is assembled by threading one joint of pipe to the next joint. The threaded portion of the joint is coated with a lubricant-sealant material supplied by the pipe manufacturer. The externally threaded joint engages the internally threaded joint, and through the use of O-rings both front and back on the externally-threaded joint, several sealing surfaces exist to ensure a leak-tight installation. The fiberglass pipeline is usually assembled in the ditch; however, it can be assembled on the surface and then lowered into the ditch. Fiberglass pipe is always installed in the trench, on a bed of select padding material, to ensure that the pipe is protected from rocks. Once in the ditch, the pipe is covered with

the padding material to a depth of six inches. After padding is complete, the trench is backfilled using the originally excavated material.

Polyethylene pipe is joined by a process known as heat fusion. Both ends of the pipe are installed in a special piece of equipment, and heated to high temperatures so that the material from each end melts together to form the joint. The joint is then allowed to cool. Polyethylene pipe is only used in the water collection system. The bonding process of the joints takes place on the surface and then the pipe is hand lowered into the ditch. The polyethylene pipe, like the fiberglass lines, is installed on a padded surface and then covered with the padding material prior to backfilling.

Backfilling the excavated material is accomplished with tractor dozers and/or track mounted backhoes. The backfilling operation begins immediately after the pipe is lowered into the ditch. The heavy equipment compacts the dirt in the trench. Once sufficient compaction has taken place, the contractor crowns the trench to ensure that sufficient dirt is available to fill in for any soil subsidence.

After the ditches are backfilled, the contractor, in conjunction with Amoco, will establish test sections for the flowline and will then subject each section of pipe to a hydrostatic pressure test. The hydrostatic test involves filling the flowline(s) with water. The water pressure is raised to 1.5 times the maximum operating pressure and held at that pressure for 8 hours. Once the test is officially started, a recording of the actual pressure applied to the pipeline is made and witnessed by an Amoco representative. All recording charts are retained as part of Amoco's recordkeeping operation. The testing equipment typically uses a water truck to haul water to the test site and a truck mounted pump to off-load the water into the flowline. Pressure test equipment is used to bring the flowline segment up to test pressure, maintain the test pressure, and record the test pressure. Once the test has officially started, it is monitored for the entire test period by an Amoco representative. If a leak is detected as a result of testing, it is located, excavated, repaired, and buried. The pressure test is then repeated to ensure the integrity of the flowline segment.

With the line successfully tested, revegetation efforts are carried out as soon as favorable weather and growing conditions exist. The revegetation program utilizes requirements established by the FS (Appendix A-1). Another stage of restoration requires the contractor to travel the completed ROW with a mechanical chipper to ensure that all brush and tree limbs are chipped and placed on the ROW. In addition, the contractor is required to pick up all trash and debris that are associated with the flowline construction. All equipment used

as part of the flowline construction and all surplus materials are removed from the ROW. As a final step, all roads that have been used for the construction of the pipelines are restored to original conditions.

The final stage of restoration involves a joint inspection and acceptance by the FS and Amoco after completion of the revegetation/cleanup phase.

A 10-man work crew would be required to install the Alternative A flowlines. Installation would likely proceed at a rate of 0.25 to 0.5 miles per day for both water and gas flowlines (Brown, personal communication, 1990). Vehicle activity associated with flowlines installation are presented in Table 2-2.

2.2.2 Viability of Alternative A

The BLM and the FS authority to implement Alternative A is limited. An explanation of this limitation and the latitude of discretion held by the agencies taken from a recent FS/BLM EIS follows below.

Background - An oil and gas lease grants the lessee the "right and privilege to drill for, mine, extract, remove and dispose of all oil and gas deposits" in the leased land, subject to the terms and conditions incorporated in the lease (Form 3110-2). Because the Secretary of the Interior has the authority and responsibility to protect the environment within federal oil and gas leases, restrictions are imposed on the lease terms (see Copper Valley Mach. Works, Inc. v. Andrus, 474 F. Supp. 189, 191; D.D.C., 1979; 653 F. 2d 595; D.D.C., 1981; Natural Resource Defense v. Bergland, 458 F. Supp. 925, 937; D.D.C., 1978).

The D.C. Circuit Court of Appeals in Sierra Club v. Peterson (717 F. 2d 1409, 1983) found that "on land leased without a No Surface Occupancy stipulation, the Department [of Agriculture] cannot deny the permit to drill; . . . once the land is leased, the Department no longer has the authority to preclude surface disturbing activity even if the environmental impact of such activity is significant. The Department can only impose mitigation measures upon a lessee who pursues surface disturbing exploration and/or drilling activities . . ." The Court goes on to say, "Notwithstanding the assurance that a later site-specific environmental analysis will be made, in issuing these leases the Department made an irrevocable commitment to allow some surface disturbing activities, including drilling and road building" (ibid., pp. 1411, 1414-1415).

TABLE 2-2

VEHICLE TYPE AND ROUND TRIP FREQUENCY FOR
FIELD DEVELOPMENT AND OPERATIONS ON NFS LANDS

Facility/Activity	Vehicle	Trip Frequency
Access Road and Well Pad Construction	Haul Truck for Dozer	2/well
	Haul Truck for Grader	2/well
	Haul Truck for Backhoe	2/well
	Gravel Truck	480/mi of road
Well Drilling, Completion, Testing, and Installation		
Well Drilling	Truck Mounted Rig	1/well
	Support Trucking	32/well
	Casing Tong Truck	1/well
	Water Truck	75/well
	Mud Truck	3/well
	Fuel Truck	2/well
	Rig Crews/Pick-up	3/day
	Rig Mechanic/Truck	1/well
	Amoco Supervisor/Pick-up	2/day
	Mud Engineers Truck	1/day
	Casing Haul Truck	1/well
	Cementers, Pump Trucks	2/well
	Bulk Truck	3/well
	Cementers/Pick-up	3/well
	Loggers/Logging Truck	1/well
	Loggers, Engineers Car	1/well
	Casing Crew Truck	1/well
	Misc. Supplies/Pick-up	2/well

TABLE 2-2
(Continued)

Facility/Activity	Vehicle	Trip Frequency
Well Completion and Testing	Completion Unit/Rig	1/well
	Completion Equipment Truck	1/well
	Completion, Crew Pick-up	12/well
	Completion Pusher	3/well
	Amoco Supervisor	2/well
	Tubing Trucks	1/well
	Service Tools	2/well
	Loggers/Truck	1/well
	Loggers/Car	1/well
	Anchor Installation	1/well
	Frac Unit	1/well
	Sand Storage Bin	1/well
	Blender	1/well
	Chemical Truck	1/well
	Sand Truck	9/well
	Manifold Truck	1/well
	Manifold Trailer	1/well
	Instrument Van	2/well
	Misc. Supplies Pick-up	4/well
Well Site Facilities Installation	Roustabout Crew Truck	2/well
	Welder Truck	5/well
	Water Truck	24/well
Flowlines Installation	Haul Truck for Dozer	2/mi of flowline
	Haul Truck for Ditcher	1/mi
	Haul Truck for Side Boom	4/mi
	Haul Truck for Track Hoe	2/mi
	Crew Pickups	21/mi
	10 Yard Dump Trucks for Padding	117/mi
Well Operations		
Well Workover	Service Unit	1/well
	Service Unit Equipment Truck	1/well
	Service Unit Crew Pick-up	2/well
	Pusher Truck	1/well
	Amoco Supervisor Pick-up	1/well
Operations	Pumper Pick-up	1/well/day

TABLE 2-2
(Continued)

Facility/Activity	Vehicle	Trip Frequency
Compressor Site Installation and Operations		
Installation	Tractor Truck	8/site
	Trailer	4/site
	Cement Truck	4/site
	Gang Truck	30/site
	2 Welding Trucks	30/site
	Pick-up	100/site
Operations	Pick-up	2/day
	Gang Truck	1/week
	Water Truck	2/month
Produced Water Collection by Truck	Water Truck	2 wells/day[a] (approx.)

[a] See Sections 2.3.1 and 2.4 for water truck activities by alternative.

Source: Amoco 1990.

In the absence of a No Surface Occupancy stipulation covering the entire lease, restrictions based on oil and gas lease operations must be "reasonable." They cannot directly or indirectly prohibit, altogether, the development of the lease. Although a given APD can be denied, the right to drill and develop somewhere on the leasehold cannot be denied by the Secretary. Authority for complete denial can only be granted by Congress (Union Oil Company of California v. Motion, 512 F. 2d 743, 750-751; 9th Cir., 1975).

Lease and Unit Stipulations - Amoco's oil and gas leases contain various stipulations concerning surface disturbance, surface occupancy, and special stipulations (regarding plan of construction and development, unstable soils, and wildlife habitat). In addition, the lease stipulations (Form 3109-5 on file at the BLM office in Durango) provide that the BLM may impose "such reasonable conditions, not inconsistent with the purposes for which (the) lease is issued, as the (BLM) may require to protect the surface of the leased land and the environment."

None of the stipulations, however, would empower the Secretary of the Interior to deny all drilling activity because of environmental concerns. The lease provisions that expressly provide Secretarial authority to prohibit the lessee from occupying portions of the leases for direct drilling occupancy are as follows:

- Within 500 feet on either side of the centerline of any and all roads and/or highways within the lease area;

- Within 200 feet on either side of the centerline of any and all trails within the lease area;

- Within 500 feet of the normal highwater line of any and all lakes, ponds, and reservoirs located within the lease area;

- Areas within 500 feet of the normal highwater line of any and all streams in the area;

(The distances in the four exclusion clauses above may be reduced when specifically agreed to in the operating plan).

- Within 400 feet of any and all springs within the lease area;

- Within 400 feet of any improvements either owned, permitted, leased or otherwise authorized by the FS; and/or

- Provisions which expressly provide Secretarial authority to deny APD development in whole or in part if a jeopardy opinion is rendered by the U.S. Fish and Wildlife Service (USFWS) for endangered or threatened species or habitats of plants or animals that are listed or proposed for listing.

Constraints on Alternative A - Conditions under which Alternative A can be considered are constrained by the level at which the authority exists to deny activity upon the lease. The Secretary of the Interior, because of the lease and unit provisions, has limited authority. Congress, on the other hand, has complete authority. For these reasons, the discussion of Alternative A has been separated into two parts. The first considers the situation where conditions exist for denial which are authorized by the lease under the authority of the Secretary. The second considers the situation in which only Congress has the authority to deny the action.

1. Alternative A - As Authorized by the Secretary of Interior

As stated above, Amoco's leases contain various stipulations which provide Secretarial authority to prohibit the surface occupancy of portions of the lease.

Section 3.0 of this draft EIS contains analysis of the presence or possible presence of land within the affected area that contains the surface resource values of concern expressly stipulated in the lease and/or unit agreement. Section 4.0 contains analysis of the adverse impacts of the proposed action and alternatives on these surface resource values.

If any one of the stipulations cannot be acceptably implemented and the impacts cannot be acceptably mitigated, then an exception could not be granted. A decision, therefore, of Alternative A as authorized by the lease, would be considered given one of the following conditions:

a. If there were no acceptable means of mitigating significant adverse impacts to the stipulated surface resource values, then this would trigger denial of further lease development and require consideration and analysis of another alternative or alternatives. Effectively, exception(s) to one or more of the lease stipulations would not be approved.

b. If the USFWS concluded that Alternative B and Alternative C would likely jeopardize the continued existence of any endangered or threatened plant or animal species, then the APD and/or lease development may be denied in whole or in part.

2. Alternative A - As Authorized by Congress

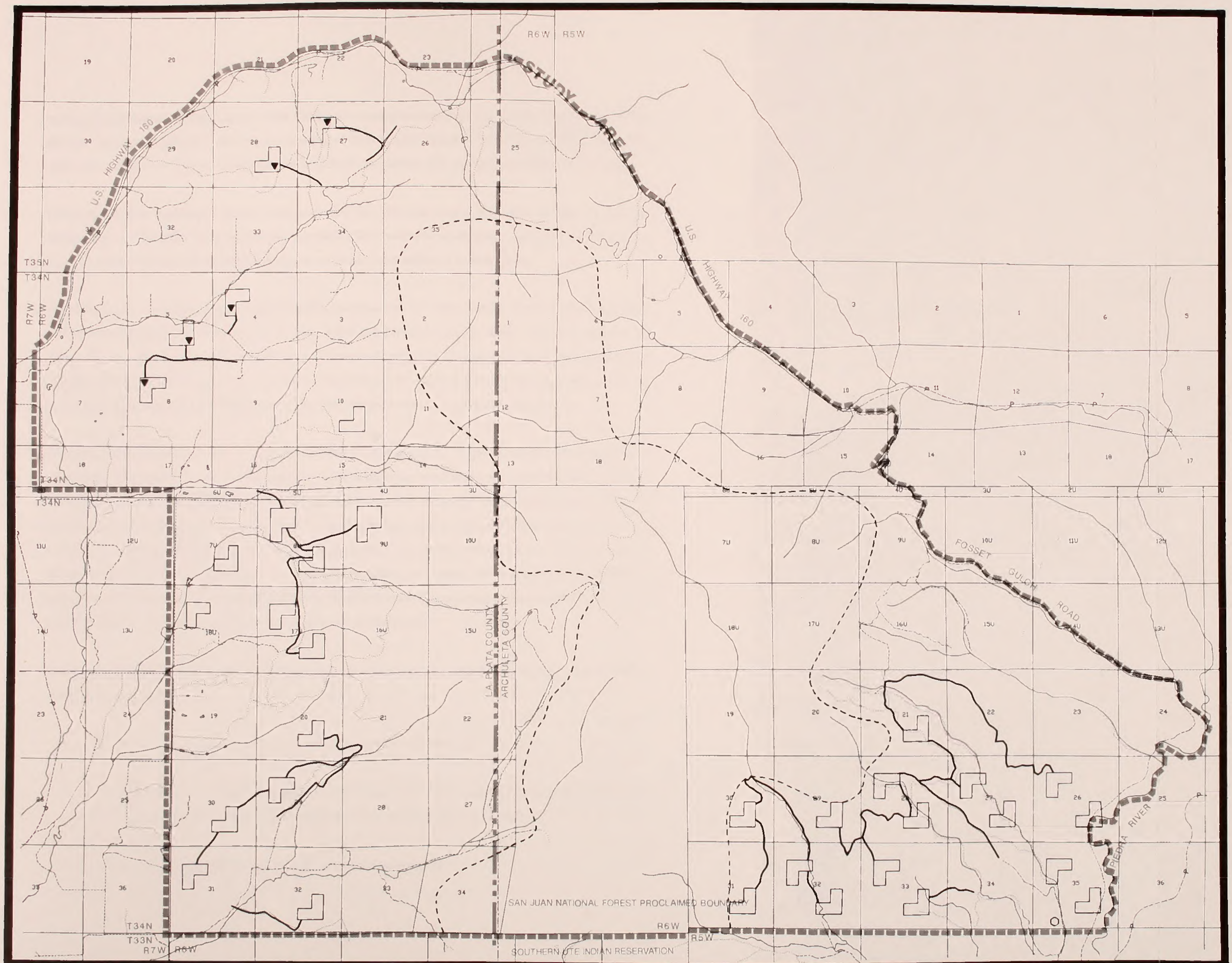
As the law now stands, the Secretary of the Interior has no authority to deny all activity upon the lease, except as described under Alternative A - As Authorized by the Secretary of Interior. To deny all activity would constitute a "taking" of an operator's rights to conduct development activities on the lease land. As the Court held in Union Oil Company of California v. Motion (512 F. 2d 743, 750-751; 9th Cir. 1975): "Congress itself can order the leases forfeited even now, subject to payment of compensation. But without Congressional authorization, the Secretary of the executive branch in general has no intrinsic powers of condemnation."

The Secretary, therefore, could only suspend the lease pursuant to Section 39 of the Mineral Leasing Act pending consideration by the Congress of a grant of authority to preclude drilling and provide compensation to the lessees.

2.3 ALTERNATIVE B - PROPOSED ACTION ALTERNATIVE

Amoco proposes to locate and drill 28 coalbed methane wells on NFS lands in 1991. The development of the wells would include new construction on NFS land of 23 miles of combined access road and flowlines ROW and well pads of approximately three acres in size. Specific locations for well pads have been identified for the five proposed wells in the Sauls Creek area and are specified in the APDs. These specific well site locations and the well spacing windows in which Amoco proposes to locate the additional 23 wells to complete their proposed program are presented in Figure 2-2. Alternative B would also include the construction of the 19 miles of flowlines to be placed in a 20-foot wide ROW adjacent to existing roads on NFS lands. These flowlines are the same as those identified in the description of Alternative A, which are required to complete connections to existing wells (Figure 2-1).

The five well sites, the 23 well windows, and the new transportation ROWs (access road and flowlines) connecting to the sites/windows comprise the potential area of direct surface disturbance for Alternative B on NFS lands. The estimated acreage of disturbance on NFS lands to result from (1) construction of the



ALTERNATIVE B-PROPOSED ACTION

ROADS (PAVED, GRAVEL, AND DIRT)

WELL WINDOWS

50-FOOT WIDE TRANSPORTATION ROW (INCLUDES ROAD AND FLOWLINES)

NATIONAL FOREST SYSTEM BOUNDARY

PROPOSED WELL LOCATION

PROPOSED COMPRESSOR STATION

UNROADED AREA BOUNDARY

NORTH

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 2-2

well pads is 84 acres, (2) construction of the 50-foot wide transportation ROW (access road and flowlines) into the 28 well sites is 141 acres, and (3) construction of 20-foot wide flowlines ROW into existing wells is 46 acres, for a total of 271 acres of probable disturbance from wellsite and transportation ROW construction.

Lease stipulations restricting surface occupancy for this alternative are the same as those listed for Alternative A. The proposed wells and transportation ROWs would be constructed, operated, and maintained in conformance with requirements/stipulations presented in Appendixes A-1 through A-4.

In addition to the 28 wells and transportation ROWs proposed on NFS land, Amoco also proposes to complete and operate six additional wells on private land in the HD Mountains Study Area. Projected acreages of disturbance on private lands to result from construction of well pads (3 acres per well) and 50-foot-wide transportation ROW (0.75 miles per well) for the six wells are 18 acres and 27 acres, respectively. All six proposed spacing windows are located within the Forest's proclaimed boundary (Figure 2-2).

During well field operations, drilled and completed wells would produce both gas and water, with the produced water to be transported by collection system flowlines or by water truck to disposal well facilities. Existing disposal well facilities are located on private land within the HD Mountains Study Area (Figure 2-1). No surface discharge of produced water is proposed. Produced gas would be separated from produced water by a separator. The gas stream would then be filtered, measured, and introduced into the gas flowline gathering system served by a compressor station. Two compressor stations, one on the Forest at the Bull Creek Federal well (Table 2-1, Figure 2-1) and one off the Forest (produced water disposal well located in Section 18,T34N, R6W) (Figure 2-1), would serve the proposed 23 wells on the Forest.

At the end of production, wells would be abandoned. At a minimum, the abandonment process would consist of the following steps:

- Surface equipment and facilities would be disassembled and removed.

- The full wellbore would be plugged/sealed with cement, or plugs would be placed strategically within the casing which was cemented in the annulus prior to completion of the well.

- Gravel surfaces of well pad and access road would be removed.

- Disturbed areas would be backfilled and graded to desired configuration.
- Surface stabilizing erosion control features would be installed as necessary.
- Surface would be tilled/prepared for seeding.
- Seed, mulch, and other materials would be added as necessary to promote the reestablishment of vegetation.

2.3.1 Description of Specific Project Facilities and Operations

The following descriptions of construction and operation of project facilities were developed based on descriptions of facilities presented in the Pargin Mountain Unit Number 11 Coalbed Methane Gas Well Environmental Assessment (FS 1990) and information provided by Amoco. Amoco information submittals are contained in the project files.

Access Road Construction - Construction of access roads would involve the use of a tractor dozer, tractor backhoe, motor patrol (road grader), and gravel trucks. The tractor dozer would follow the selected routes, rough shaping the general road prism to the proposed well locations. The tractor backhoe would then set culverts for drainage, burying them to a sufficient depth to ensure that they functioned deep enough as not to be damaged or destroyed by future traffic. The motor patrol (road grader) would then begin final shaping of the road prism. Subsurfacing gravel would then be placed on the shaped 20-foot wide road prism. Gravel trucks would bring large sized (6-inch and less) gravel to dump on the shaped road surface. The subsurface gravel would lend structural support to the soil, allowing the use of the road during wet periods. A final 4-inch depth of fine crushed gravel (1-inch and less) would then be applied over the larger material. This fine gravel would provide a surface that can be maintained without damaging the structural support of the larger gravel. The top surface layer would not be applied until the larger material had an opportunity to compact. This type of compaction could be achieved by allowing other types of traffic to operate on it.

Construction of the access roads and the well pad (detailed below) would require the use of heavy equipment and support vehicles by 3 five-man crews. Dozer, grader, and backhoe activity would occur along the road ROW for a duration period/rate of seven days per mile of road. An average of two round trips per road segment construction would be required for the dozer's, grader's, and backhoe's haul trucks. To surface the

road and well pad with gravel, approximately 480 round trips by gravel trucks would be required per mile of access road. An average of three in-and-out trips per day by management and worker vehicles (pickups) would occur for the duration of road construction.

Wellpad Construction - A disturbance area of roughly 350 feet by 350 feet would be created during wellpad construction by the tractor dozer once it has completed the rough construction work on the access road. The process used would be to strip off the topsoil, using the dozer, and stockpiling for reclamation use. The flat two-acre area of the well pad would be shaped, and the reserve pit dug and lined to make it impermeable to leaks. A fence around the reserve pit would be erected. Road reconstruction and well pad construction would take place simultaneously.

Well Drilling - The active phase of drilling would begin with setting the four tie down anchors to guy the derrick tower and digging a rectangular pit, called a cellar, where the hole would be drilled. The cellar would provide space for the casing head spools and blow-out preventers that would be installed under the rig. In the middle of the cellar, the first part of the well has actually begun, but not necessarily with the drill rig. Instead, a small truck mounted rig may be used to start the first part of the hole which is large in diameter but shallow in depth (the hole is "spud in"). Another hole would be dug off to the side of the cellar. It is called the rathole and would serve as a place to temporarily store a piece of drilling equipment called the Kelly.

The next step would be to move the drill rig to the site. Trucks would be used to transport various components to the work site. Rig components are designed for portability and are easily loaded and unloaded. The rig would be assembled beginning with the substructure draw works; power supply, mast, mud tanks, walkways, and guardrails would complete the assembly. Auxiliary equipment for the supply of electricity, compressed air, and water is made ready for operation. The large pumps (mud pumps) that would circulate the drilling fluid are put into place. Storage racks, bins, and office trailers for the tool-pusher and the company workforce are moved to the site. Drill pipe, drill bits, mud components, wire rope, and other needed supplies are trucked in to the wellpad.

The drill rig is made up of four main system components: power, hoisting, rotating, and circulation. The power system uses diesel internal combustion engines to provide power for the other systems to operate. The hoisting system is made up of the draw works (sometimes called the hoist), a mast or derrick, the crown block, the traveling block, and wire rope. The hoist is used to raise and lower the drill pipe and bit. The rotating system consists of the swivel, a four- or six-sided pipe called the Kelly, the rotary table, the drill pipe, drill

collars, and the bit. The circulation system consists of a large number of mechanical items to circulate the drilling fluid. The drilling fluid, often called mud, is a mixture of water, bentonite, barite, and polymers. Caustic soda and soda ash are used in controlled amounts to maintain the properties of the mud, i.e., mud weight, fluid loss, viscosity, and pH.

Potentially toxic substances used in the development or operation of wells would be kept in limited quantities on wellsites. An example is caustic soda (Na_4OH) used to change the pH of drilling mud. EPA regulates the use of toxic substances and requires the operator to follow the Materials Safety Data Sheets for all toxic substances. Occupational Safety and Health Administration (OSHA) requirements also regulate these materials. Certification or other approvals issued by federal or state agencies or compliance with and regulations relating to drilling operations above and beyond the requirements of stipulations in Appendixes A-1 through A-4 will be accepted.

Drilling mud serves several very important functions. Mud is used to raise the cuttings made by the bit and lift them to the surface for disposal. But equally important, mud also provides a means for keeping underground pressures in check. The heavier or denser the mud is, the more pressure it exerts. Water is the fluid used to mix with the other components to make the mud. Bentonite, a naturally occurring clay, is used to keep the cuttings in suspension as they move up the hole. It also sheaths the wall of the hole, promoting hole stabilization, and controls viscosity and fluid loss into the formation. Barite ($BaSO_4$) is a mineral used to increase the weight of the drilling mud. Its specific gravity is 4.2 (4.2 times heavier than water). Polymer additives are used to control fluid loss and to keep the other materials in suspension. The caustic and the soda ash are used to control the pH, viscosity, and act as a catalyst for the other constituents of the drilling mud.

Drilling operations normally include (1) keeping a sharp bit on bottom drilling as efficiently as possible, (2) adding a new joint of pipe as the hole deepens, (3) tripping the drill string out of the hole to put on a new bit and running it back to the bottom, and (4) installing casing and cementing in the hole. Typically, a 12 1/4-inch (diameter) hole is drilled to a depth of 250 feet where 8 5/8-inch steel casing is run and cemented in place. A 7 7/8-inch hole is subsequently drilled to total depth where 5 1/2-inch production casing is run and cemented into place. Production casing is used to contain produced fluids and prevent them from migrating uphole. When the steel casing is lowered into the hole, a specially designed cement for use in oil and gas operations is carefully mixed and pumped down the inside of the casing behind a special plug that wipes the casing and pushes the drilling mud ahead of the cement. Upon reaching bottom, the plug shears under pressure and allows the cement to be circulated to the surface between the wellbore and the outside of the casing. After pumping

the cement, a second plug (top plug) is pumped to the bottom of the wellbore removing any residual cement from the walls of the casing and ensuring that drilling fluids do not contaminate the integrity of the cement job. When completed, the entire wellbore is cased and cemented into place with steel pipe.

Prior to placement of the casing, the well would be logged from approximately 200 to 300 feet (depending on the depth of surface casing) below the surface to its total depth below the surface. This evaluation enables Amoco to determine if the well contains enough gas to make it economically feasible to complete the well. Well logging uses a truck mounted laboratory, and lowers devices called logging tools into the well on a wireline. The logging tool is capable of taking certain measurements of the rock formations it passes. The tools are lowered to the bottom of the hole and then reeled up slowly. As the logging tool is retrieved, electrical signals are transmitted through the cable to the surface, where they are recorded on film or digitally stored in a computer. The data are used to make a log showing the recorded measurements at all points throughout the depths tested. These measurements are used to analyze the various rock properties of the formations, such as porosity, fluid saturation, and lithology (mineral identification and structure of the rock). Once this testing is complete, Amoco would decide to complete the well or to plug and abandon it. If the decision is to abandon, it is necessary to secure permission from the BLM, who would set the standards to be met for abandonment of wells on federal land.

Amoco has proposed to use four drill rigs in the completion of their field development plans. Two rigs would likely be used in the Pargin Mountain area, the southeastern portion of the Study Area, and single rigs would likely be used in the northwestern and southwestern quarters of the Study Area. Approximately eight days would likely be required to drill each coalbed methane well. An estimated six to 19 individuals would be involved in the drilling of each well. Vehicular activity for drilling, defined as round trip frequencies per well or per day, is presented in Table 2-2.

<u>Well Completion and Testing</u> - After a well is drilled, a well completion and testing program is initiated to stimulate production and to determine water and gas production characteristics. A mobile completion rig similar to the drill rig is the focal piece of equipment around which a well completion program is conducted. The well completion process, lasting 7 to 14 days, includes perforating the well's steel casing, fracturing the producing formation, and installing a series of valves and fittings on the wellhead (called a "Christmas tree").

Perforations are holes that are made through the casing and cement, and that extend some distance into the production zone. Perforations must be made for the gas to flow into the wellbore. The most common method

of perforating incorporates shaped-charge explosives. Fracturing is a method of stimulating production by increasing the permeability of the producing formation. In hydraulic fracturing, water is pumped under extremely high pressure downward through the tubing and out through the perforations in the casing. The pressurized fluid enters the formation and parts or fractures it. Sandgrains, aluminum pellets, glass beads, or similar materials are carried in suspension by the fluid into the fractures. These are called proppants. When the pressure is released at the surface, the fracturing fluid returns to the well, and the fractures partially close on the proppants, leaving channels for gas to flow through them into the well. Installing the "Christmas tree" and associated tubing is the final step of the wellbore work.

Even though the produced water and gas can flow into the casing after it is perforated, a small diameter pipe, called tubing, is placed in the well to serve as a way for the produced water to be brought to the surface. The tubing is run into the well. Typically, tubing is placed below the perforated interval to allow any fluid entry to be pumped up the tubing to the surface. At the surface, the collection of valves ("Christmas tree") sits at the top of the casing. The tubing in the well is suspended from the "Christmas tree," so as the well production flows up, it enters the "Christmas tree." As a result, the production from the well can be controlled by opening and closing valves on the "Christmas tree."

All completion activities would be limited to daylight hours. There would be minimal flaring of gas at wellsites during completion and/or well connection to flowlines. Water produced during completion will be stored in tanks or lined reserve pits for subsequent transport to disposal facilities. An estimated five to 20 individual workers would be required for each well completion. Required vehicles and estimated trip frequencies for well completion and testing are presented in Table 2-2.

After completion, the liquid in the lined reserved pit would be allowed to settle out the drilling muds and drill cuttings. Once separated, the liquids would be evaporated on site. Once dry, the reserve pit would be closed, covering the drill cuttings and drilling mud with the banks of the reserve pit. All areas not needed for production facilities would be topped with the previously stored topsoil. Seeding of these areas would take place in the fall.

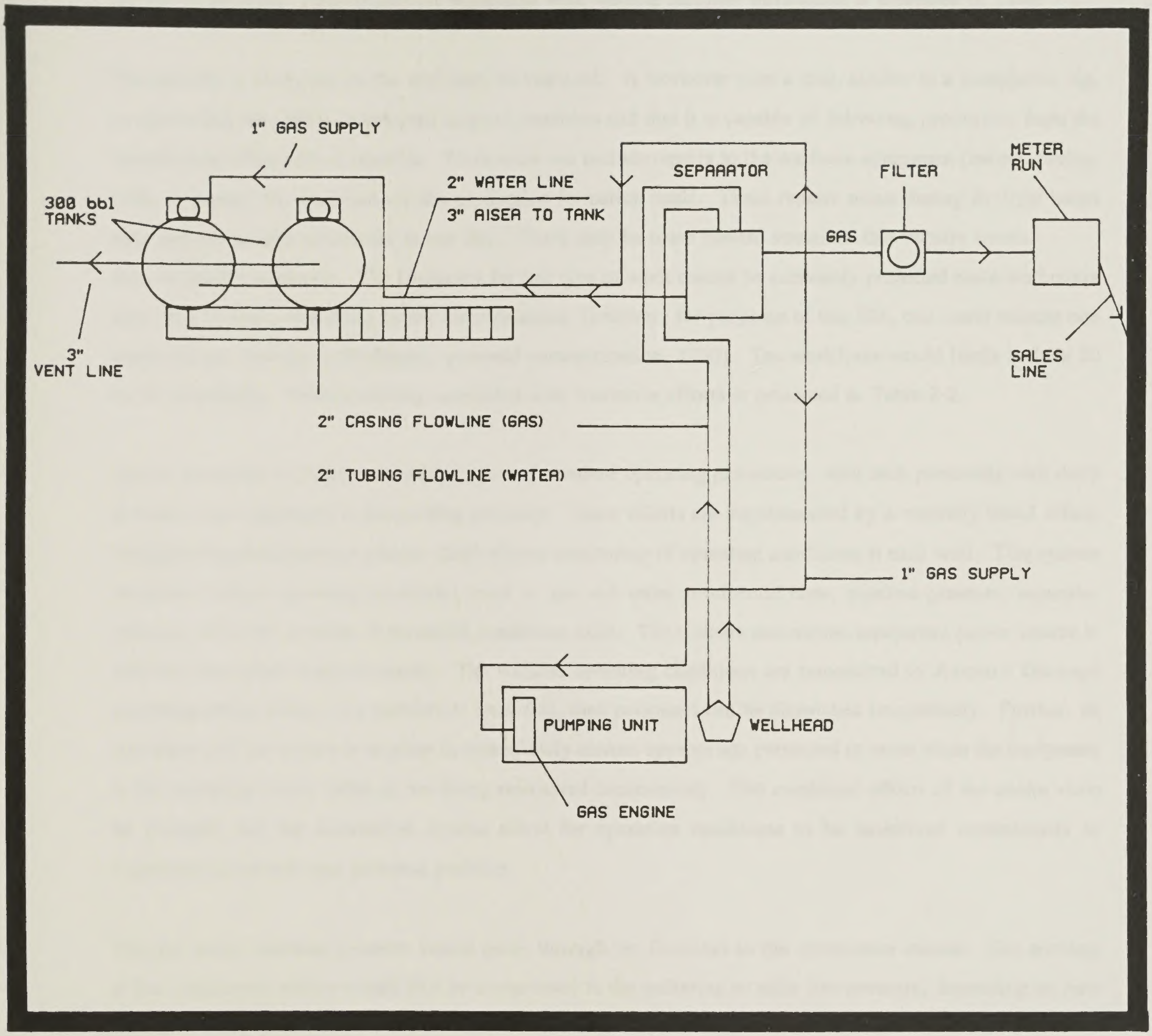
<u>Gas Production, Treatment, Collection, and Compression</u> - Installed surface production facilities would include the previously mentioned wellhead facility ("Christmas tree"), a walking beam pumping unit (pump jack and engine), separation and/or dehydration facilities, produced water tanks, and a connection to the gas and/or water collection system (Figure 2-3). All occupy less than one acre. The walking beam pump

is powered by a propane or produced gas fired 40- to 48-horsepower reciprocating engine. This pump is used to lift the produced fluid stream from the production zone, allowing the gas to flow by reducing the hydrostatic pressure on the coals.

The workforce associated with the installation of equipment and flowlines would likely be about 29 individuals. For the installation of production equipment, 3 three-man crews would follow well completion and testing operations. Two ten-man crews would install flowlines. Vehicle activity associated with equipment and flowlines installation is presented in Table 2-2.

The produced fluid stream contains water and natural gas. Since coalbed methane is a new technology, no long term production history exists to definitively state specific trends in production performance in this area. Generally speaking, though, the well gas rate should incline the first few years, then gradually decline (Brown, personal communication, 1991). The water rate should decrease rapidly for the first few years then stabilize to relatively low levels during the life of a well (Clark and Hemler 1988; Decker et. al. 1988). The produced stream requires the separation of water in a two-phase separator at the wellsite which would yield gas and produced water. Following separation, the gas is filtered, metered, and introduced into the gathering system. Gas flowlines of the gathering system would be constructed of fiberglass for flowlines ranging from 3 inches to 6 inches in diameter, and of steel for 8 inches up to 20 inches nominal sizes. The sizes vary depending on the volume of gas expected to be transported. Should storage of produced water in tanks not be required, produced water would be introduced directly into the water flowlines gathering system (Figure 2-4). Both the gas and water flowlines would typically be placed, to the extent possible, in the same ditch providing a minimum 4.5-feet cover on top of the pipe within the flowlines corridor. Procedures for flowlines ROW clearing, pipelines installation, and ROW reclamation would be the same as those discussed for Alternative A.

The produced water is a distinctive bicarbonate type connate water (Rice et al. 1988). Although the water produced from methane gas wells is a sodium bicarbonate type water with total dissolved solid concentration much lower than most oil field brines, it too is sometimes referred to as brine. The daily water production for these types of wells can range from 10 to 400 barrels with an average of 70 barrels per well (Zimpfer et al. 1988). Approximately one-third of the available in-place water in the geologic formation would be removed from a well's zone of influence during the life of the well's production (Jones et. al. 1988). However, only about 3 percent of the available water in-place basin wide would be removed (Hoffman, personal communication, 1989). Waters are transported to approved disposal wells or evaporation pits for disposal. The remaining on-site facilities on the surface are an outhouse-sized meter house to measure the gas, and an



SOURCE: AMOCO 1990

TYPICAL PLOT PLAN FOR AN OPERATING COALBED METHANE GAS WELL LOCATION- PRODUCED WATER HAULED AWAY FOR DISPOSAL BY TRUCK

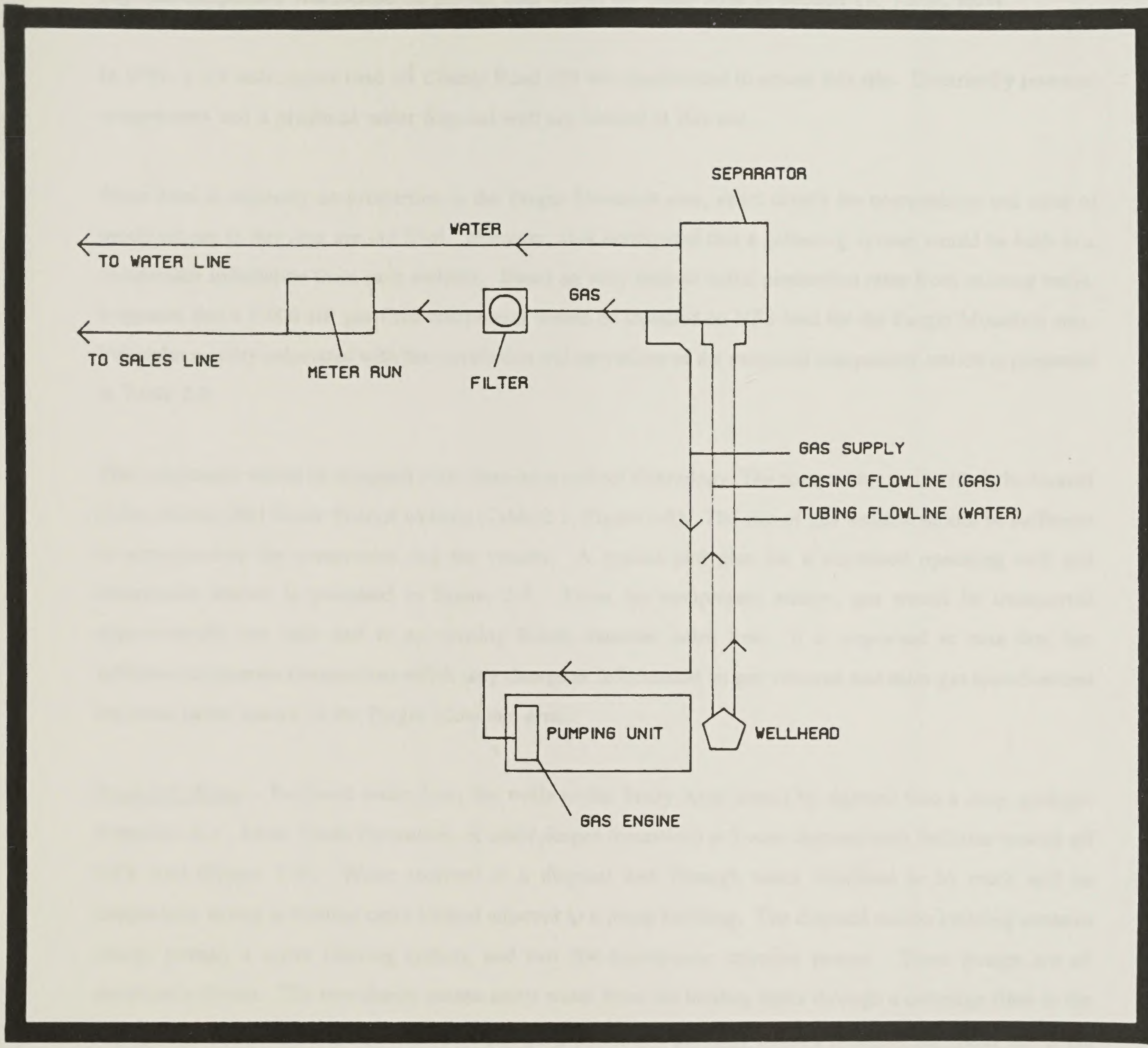
FIGURE 2-3

antenna with a solar panel mounted on a 15-foot tall pole, used to send data from the well and to enhance control of the well. Vehicle activity associated with wellsite facilities installation is presented in Table 2-2.

Periodically, a workover on the well may be required. A workover uses a unit, similar to a completion rig, to ensure that the well is maintained in good condition and that it is capable of delivering production from the formation as efficiently as possible. Workovers can include repairs to the wellbore equipment (casing, tubing, rods, or pump), the wellhead, or the production formation itself. These repairs occur during daylight hours only and are usually completed in one day. There may be some limited situations that require several days to finish a workover. The frequency for this type of work cannot be accurately projected since workovers vary well by well, depending on the circumstances. However, for purposes of this EIS, one could assume one workover per year per well (Brown, personal communication, 1990). The workforce would likely include 10 to 15 individuals. Vehicle activity associated with workover efforts is presented in Table 2-2.

Amoco personnel or pumpers would, as part of standard operating procedures, visit each producing well daily to ensure that equipment is functioning properly. These efforts are supplemented by a centrally based offsite computer-based automation system which allows monitoring of operating conditions at each well. This system monitors various operating conditions (such as gas and water production rates, pipeline pressure, separator pressure, etc.) to determine if abnormal conditions exist. The wellsite automation equipment power source is derived from solar mounted panels. The wellsite operating conditions are transmitted to Amoco's Durango operating center office. If a problem is identified, then personnel can be dispatched immediately. Further, an automatic call out system is in place to immediately contact appropriate personnel in cases when the equipment at the operating center office is not being monitored continuously. The combined efforts of the onsite visits by pumpers and the automation system allow for operation conditions to be monitored continuously to expeditiously remedy any potential problem.

The gas under wellhead pressure would move through the flowlines to the compressor station. Gas arriving at the compressor station would first be compressed to the gathering or sales line pressure, depending on how the gas is marketed.



SOURCE: AMOCO 1990

TYPICAL PLOT PLAN FOR AN OPERATING COALBED METHANE GAS WELL LOCATION-PRODUCED WATER PIPED AWAY FOR DISPOSAL

FIGURE 2-4

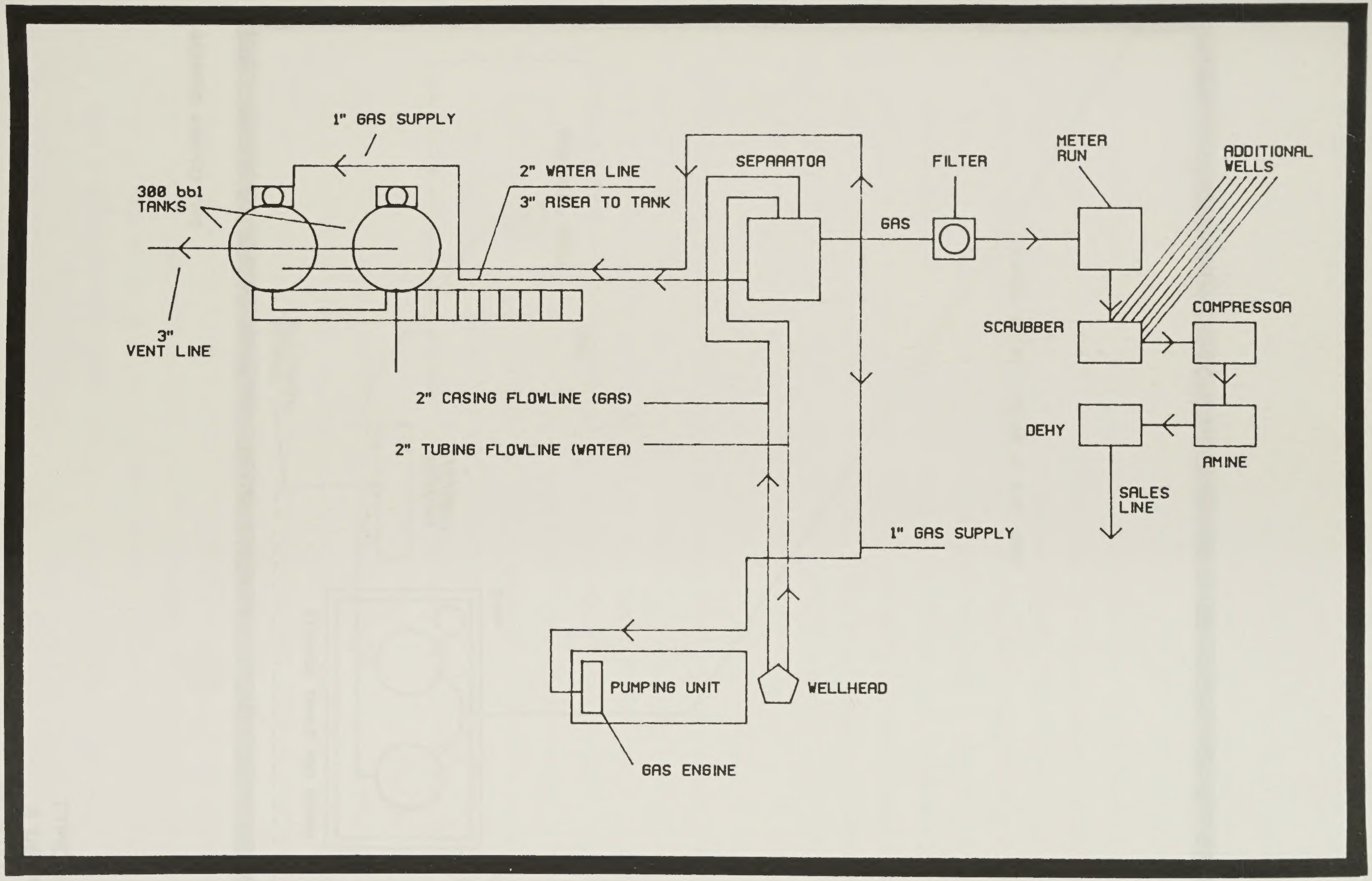
Compression needs for development in the western half of the HD Mountains would be provided by the Amoco Bayfield compressor site located on private land within the Study Area in Section 18, T34N, R6W.

In 1989, a 1/4-mile access road off County Road 523 was constructed to access this site. Electrically powered compressors and a produced water disposal well are located at this site .

Since there is currently no production in the Pargin Mountain area, exact details for compression and sales of produced gas in this area are not final. However, it is anticipated that a gathering system would be built to a compressor installation from each wellsite. Based on very limited initial production rates from existing wells, it appears that a 1,000 HP gas-fired compressor would be installed on NFS land for the Pargin Mountain area. Vehicular activity associated with the installation and operations of the proposed compressor station is presented in Table 2-2.

The compressor would be equipped with clean-burn control technology. The compressor would likely be located at the existing Bull Creek Federal wellsite (Table 2-1, Figure 2-1). The size of this wellsite should be sufficient to accommodate the compressor and the vessels. A typical plot plan for a combined operating well and compressor station is presented in Figure 2-5. From the compressor station, gas would be transported approximately one mile east to an existing 8-inch diameter sales line. It is important to note that this information contains assumptions which may change as information on gas volumes and sales gas specifications becomes better known in the Pargin Mountain area.

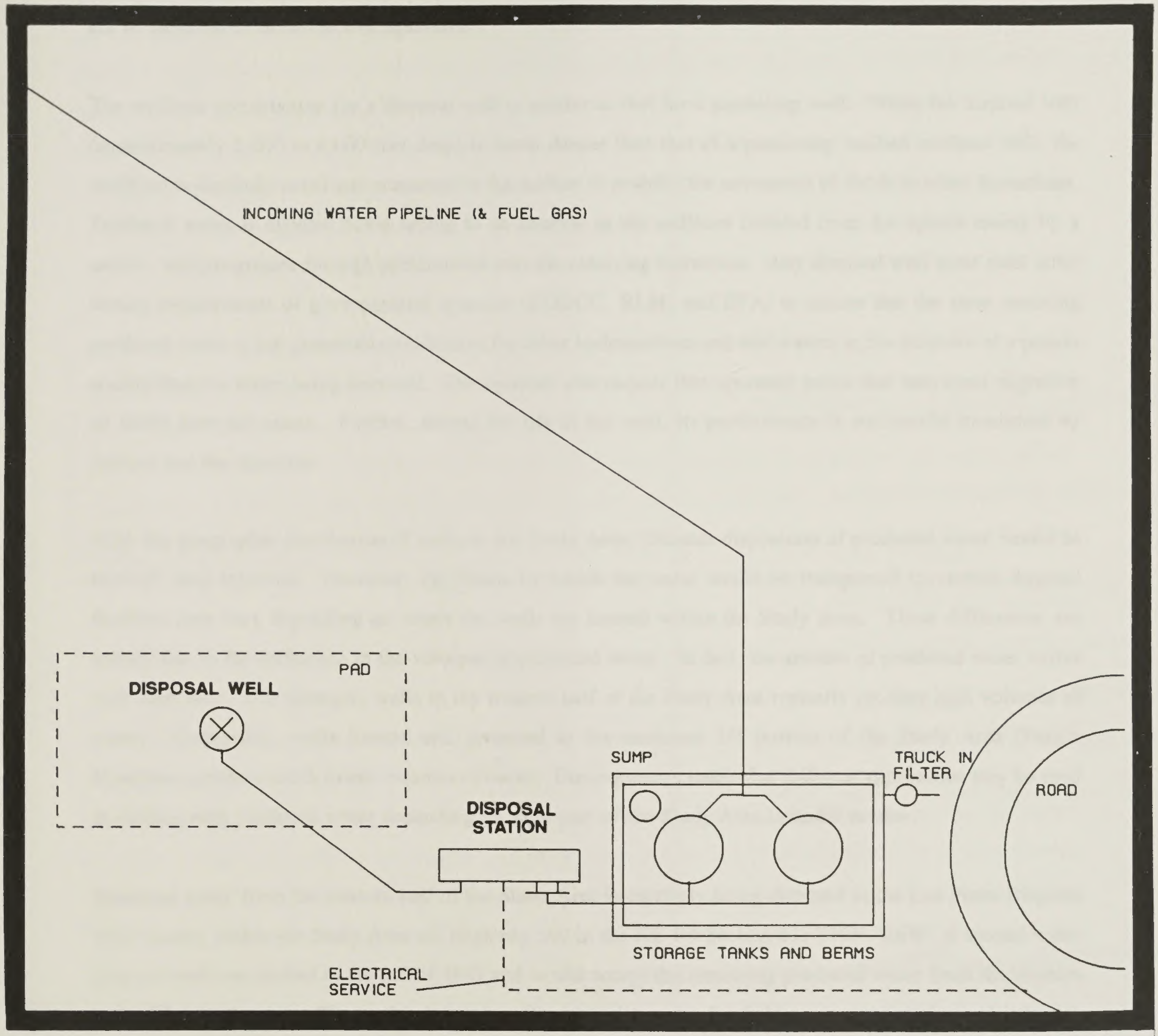
Produced Water - Produced water from the wells in the Study Area would be injected into a deep geologic formation (i.e., Mesa Verde Formation, or other deeper formation) at 3-acre disposal well facilities located off NFS land (Figure 2-6). Water received at a disposal well through water flowlines or by truck will be temporarily stored in holding tanks located adjacent to a pump building. The disposal station building contains charge pumps, a water filtering system, and two 200-horsepower injection pumps. These pumps are all electrically driven. The two charge pumps move water from the holding tanks through a cartridge filter to the high pressure triplex pumps. The triplex pumps generate the pressure needed to inject the water down the disposal well and into the formation. The facilities operate 24 hours a day. Disposal stations generally have the capacity to inject 10,000 barrels of water per day. A typical disposal well facility is equipped with a skid-mounted, water-disposal station housing the equipment described above, two 1,000-barrel water holding tanks, and a 90-barrel steel sump for collecting operational wastes. The sump is routinely pumped out, with contents being hauled to an approved disposal site. The two 1,000-barrel water



SOURCE: AMOCO 1990

TYPICAL PLOT PLAN FOR A COMBINED OPERATING COALBED METHANE GAS WELL (UNCONNECTED TO A WATER COLLECTION SYSTEM) AND COMPRESSOR STATION

FIGURE 2-5



SOURCE: AMOCO 1990

TYPICAL PLOT PLAN FOR A DEEP DISPOSAL WELL FACILITY FOR THE DISPOSAL OF PRODUCED WATER

FIGURE 2-6

tanks are each heated during winter months by a 500 MBTU/hr natural gas fired heater. All facility buildings and external nongalvanized equipment are, to the greatest extent practical, painted Federal Specified Green or are constructed of nonreflective materials.

The wellbore construction for a disposal well is similar to that for a producing well. While the disposal well (approximately 5,000 to 9,000 feet deep) is much deeper than that of a producing coalbed methane well, the wellbore is similarly cased and cemented to the surface to prohibit the movement of fluids to other formations. Produced water is injected down tubing to an interval in the wellbore isolated from the uphole casing by a packer, and progresses through perforations into the receiving formation. Any disposal well must meet strict testing requirements of governmental agencies (COGCC, BLM, and EPA) to ensure that the zone receiving produced water is not potentially productive for other hydrocarbons and that waters in the zone are of a poorer quality than the water being disposed. The agencies also require that operators prove that interzonal migration of fluids does not occur. Further, during the life of the well, its performance is continually monitored by Amoco and the agencies.

With the geographic distribution of wells in the Study Area, ultimate disposition of produced water would be through deep injection. However, the means by which the water would be transported to various disposal facilities may vary depending on where the wells are located within the Study Area. These differences are mainly due to the difference in the volumes of produced water. In fact, the amount of produced water varies with each well. For example, wells in the western half of the Study Area typically produce high volumes of water. Conversely, wells located and proposed in the southeast 1/4 portion of the Study Area (Pargin Mountain) produce much lower volumes of water. Consequently, somewhat different approaches may be used in dealing with produced water depending on what part of the Study Area is under review.

Produced water from the western half of the Study Area is currently being disposed in the Los Pinos Disposal Well located within the Study Area off Highway 160 in the NE 1/4 Section 31, T35N, R6W. A second water disposal well was drilled in the fall of 1989 and would accept the remaining produced water from the western half of the Study Area. The well is located on the same site as the Bayfield compressor station and is known as the Bayfield Disposal No. 1. The facility is located within the western portion of the Study Area in the SE 1/4 Section 18, T34N, R6W, on private land. The combined compressor and water disposal facility received permit approval pursuant to the La Plata County Oil and Gas Regulations. Water hauling to the site would be limited to an average of one trip per day.

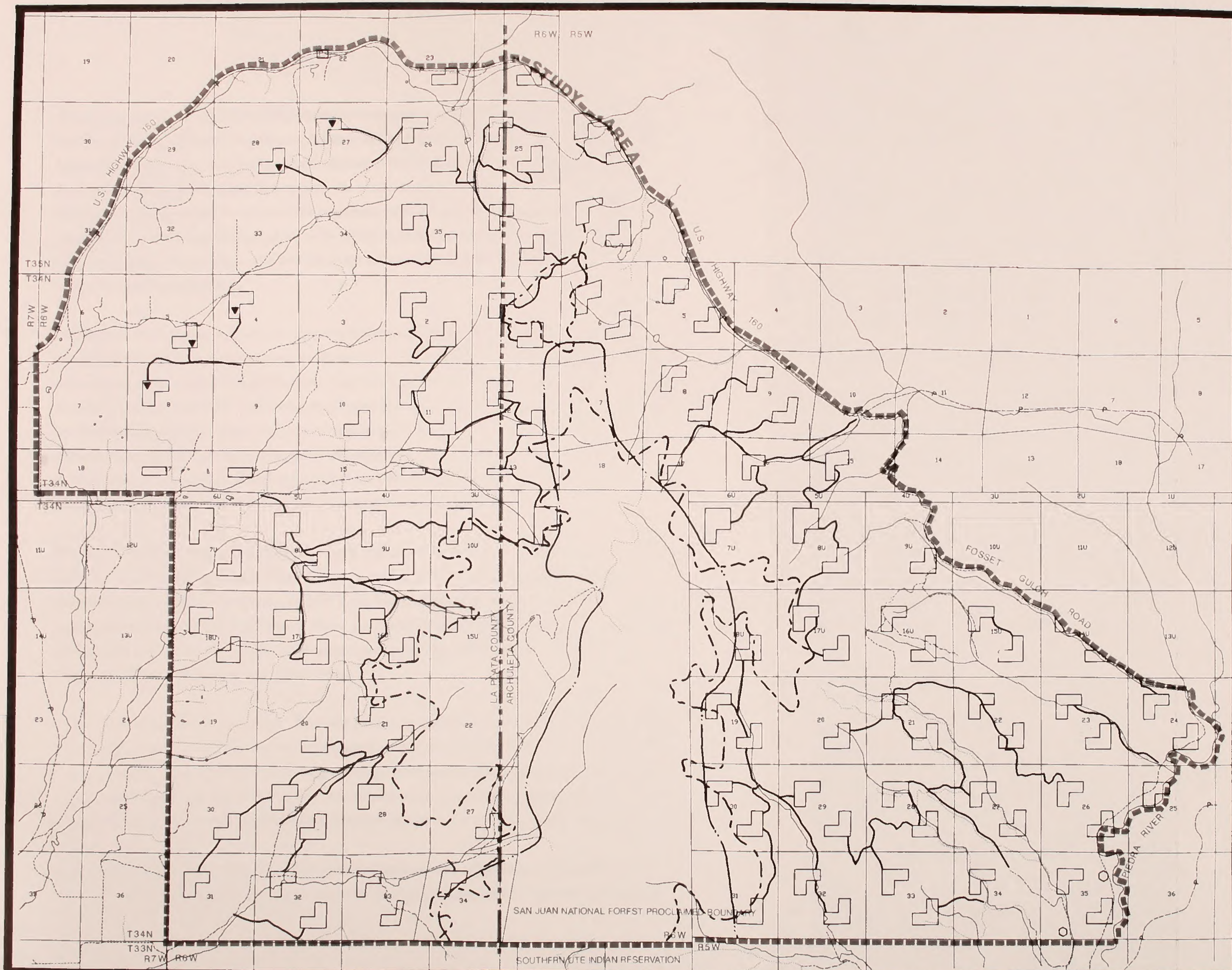
Pipe flowlines carrying produced water from the separator at each well to the disposal facility would typically be polyethylene and/or fiberglass with diameters ranging from approximately 3 inches to 6 inches, depending on the flow volumes. Pressure to move the water through the water pipelines to the storage tanks and the disposal well would be produced either hydrostatically or by the back-pressure maintained on the wellhead separator. Water flowlines connecting the wellsite with the gathering system for water disposal will be placed in a flowline ROW approved by the FS or in ROW easements obtained from private landowners. The flowlines ROW corridor width would normally be 20 feet. There are approximately 6 miles of flowline ROW existing within the Study Area on NFS lands, with another approximately 19 miles currently being added on NFS lands. A total of approximately 25 miles of flowline would be installed on NFS lands in the Study Area.

Produced water from wells in the Pargin Mountain area (southeastern portion of the Study Area) would not be connected into a gathering flowlines system as planned for the western half of the Study Area. Produced water would be trucked from a single 400-barrel storage tank located on each wellsite. Since the wells in the Pargin Mountain area are expected to produce an average of 15 to 30 barrels of water per day, water haul truck traffic is expected to average six round trips per day when all 16 wells (existing and proposed) are drilled and producing. The trucked water would be taken to an approved disposal well on private land for disposal. There are no current plans to drill a disposal well in the Pargin Mountain area.

2.4 ALTERNATIVE C - CURRENT DIRECTION ALTERNATIVE

This alternative was initially developed in response to an issue regarding a need to study the effects of full project area development for the coalbed methane gas field. It was modified to reflect the area which is technically and economically feasible for production. As modified, this alternative would involve the potential development of 95 coalbed methane gas wells on NFS lands over the next seven years. Completion of the 95 wells under the state spacing requirements on NFS lands, and ancillary facilities consisting of access roads, flowlines, and compressor stations, would represent the actions undertaken for this alternative (Figure 2-7). Development of one additional well on state land and 20 additional wells on private land would complete feasible development within the HD Mountains Study Area.

Stipulations restricting surface occupancy for leases covering this alternative are the same as those listed for Alternative A. The proposed wells and transportation ROWs would be constructed, operated, and maintained in conformance with requirements/stipulations presented in Appendixes A-1 through A-4.



ALTERNATIVE C-CURRENT DIRECTION

ROADS (PAVED, GRAVEL, AND DIRT)

WELL WINDOWS

50-FOOT WIDE TRANSPORTATION ROW (INCLUDES ROADS AND FLOWLINES)

NATIONAL FOREST SYSTEM BOUNDARY

ECONOMIC DEVELOPMENT EXCLUSION ZONE BOUNDARY

PROPOSED COMPRESSOR STATION

UNROADED AREA BOUNDARY

NORTH

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE **2-7**

Amoco has identified an area within the HD Mountains Study Area totally on NFS lands that would be excluded from future development based on producing-formation depth of burial. Performance from existing wells and limited permeability testing have indicated that coals deeper than 4,000 feet (depth to coal pay) do not have the flow capacity needed for economic development. The exclusion zone, as presented in Figure 2-7, defines the 4,000 foot burial area which is associated with topography of higher elevations known as the HD Mountains (Appendix B). These mountains occupy the center of the Study Area and contribute an extra 1,000 to 2,000 feet of overburden over the coals. A discussion of the technical and economic components of this exclusion zone is presented in Appendix B.

Development of 95 coalbed methane gas wells would occur over the next seven years. Twenty-eight wells would be drilled in the first year (Alternative B), and 11 to 12 wells per year would be drilled during the remaining six years. Road access and flowlines connection to all 95 wells would include the construction of 52 miles of transportation ROW (this includes the 23 miles of ROW for Alternative B of combined access road and flowlines ROW connecting to well pads of approximately 3 acres in size). The construction of two compressor stations would be required as part of full implementation of Alternative C. One would be located on NFS lands on the existing well pad of the Bull Creek Federal well location (Table 2-1, Figure 2-2.) No additional land disturbance would be required for construction and operation.

The second compressor station would likely be located on private land near the West Gas sales pipeline in the southeast corner of the Study Area (Figure 2-7). This facility would consist of a compressor, a glycol dehydration unit, a glycol regenerator (120 MBTU per hour), an amine treatment system, and an amine regeneration system (4 MMBTU per hour.) Three acres and 0.25 miles would be required for the site and 20-foot wide access road respectively. Both compressors would be 1,000 HP units. Descriptions of the compressor station's components are presented below.

- Compressor station compressor. The main function of compression facilities is to deliver gas at a higher pressure for transmission through pipelines than pressures existing at the wellhead. This function is typically accomplished using natural gas-fired engines or electric motors which can drive reciprocating type piston compressors, screw compressors, or centrifugal compressors. Associated equipment may include dehydration and amine systems for water and CO_2 removal, respectively.

- Glycol dehydration. The dehydration process consists of water-saturated gas entering the bottom of the dehydrator unit and traveling upward countercurrently to a liquid glycol stream moving downward.

As the glycol flows downward it absorbs water from the gas moving in the opposite direction. This process is called dehydration, as water is removed from the gas stream. Once the process is completed, the dehydrated gas leaves the top of the unit. The water rich glycol leaves the bottom of the absorber and is piped to the heated reboiler system where the water is evaporated.

- Glycol regeneration. The water-rich liquid glycol is heated and the water is vaporized and separated from the glycol until the desired concentration of lean glycol is produced. The water-lean liquid glycol is then recirculated to the dehydration system in a continuous process.

- Amine treatment system. A common process for treating gas uses a chemical solution called amine to remove carbon dioxide (CO_2) from the gas. Different compositions of amine solution can be used, but DEA (diethanolimine) is most typical. Amine systems consists of two distinct phases, treating and regeneration. During treating, the produced gas stream and liquid amine (DEA) are contacted countercurrently in the amine contractor. As a result of chemical reactions between the produced gas stream and amine, the CO_2 in the produced gas is absorbed into the amine solution. The amine solution containing the CO_2 then passes to the amine regenerator for CO_2 removal.

- Amine regeneration. During amine regeneration, the chemical reaction that took place in the contactor is reversed by adding heat. The vaporized CO_2 is released and vented. The amine, which is now regenerated, is then recirculated to the treating section to continue the process.

As described in discussions of produced water disposal in Section 2.3.1, water produced from wells drilled in the western half of the Study Area would be collected in a flowlines gathering system and piped to one of the two disposal wells located in the western half of the Study Area. Assuming full development of Alternative C, 53 wells on NFS lands and 12 wells on private lands would be connected.

Produced water from those wells in the eastern half of the Study Area would not likely be connected into a water gathering system; a gas gathering flowline system would be installed. Produced water would be trucked to the disposal well(s) located in the western half of the Study Area or to other disposal weils located outside the Study Area. An estimated 30 barrels of water per day would be produced initially by each of 48 wells (six existing and 42 proposed) on NFS lands, and nine wells on private and state lands, assuming full development of the alternative. Water haul traffic is expected to average 22 round trips per day when all 57 wells are drilled and producing.

Alternative C would also include the construction of the 19 miles of flowlines to be placed in a 20-foot wide ROW adjacent to existing roads. These flowlines are those identified in the description of Alternative A as being required to complete connections to existing wells on NFS lands.

Additional procedures for construction, operation, and abandonment activities to be conducted with the implementation of this alternative will be the same as those described for Alternative B.

The five wellsites, 90 well windows, and the transportation ROWs connecting to the sites/windows make up the potential area of direct surface disturbance for this alternative. The estimated acreage of disturbance on NFS lands resulting from implementation of this alternative is 285 acres for the wellsites (pads), 315 acres for the transportation ROWs, and 46 acres for the additional flowlines ROWs to complete connections to the existing wells.

2.5 ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL

In addition to the three previous alternatives, five additional alternatives were considered but not analyzed in detail due to identified limitations which minimize the feasibility of their implementation. The five alternatives are as follows:

1. Development of 33 wells and ancillary facilities on NFS lands as an addition to the Current Direction Alternative;

2. Helicopter access to well sites for construction, well development, operations and maintenance, and abandonment;

3. Use of directional drilling to access the coalbed pay zone beneath adjacent windows;

4. Surface disposal of produced water onto land or into streams or other water bodies; or

5. Disposal of produced water by evaporation from constructed evaporation ponds.

The development of wells in 33 windows on NFS lands at the higher elevations of the HD Mountains was currently determined to be technically and economically infeasible due to the excessive thickness of overburden

and depth to the Fruitland Formation. A zone of exclusion within the Study Area is delineated on Figure 2-7. The addition of the 33 wells would result in the complete occupancy of all possible drilling windows within the HD Mountains Study Area, for a total of 128 wells on NFS land.

Helicopters were proposed as an alternative method to access the possible well pads thereby reducing the road miles needed for development. This alternative was considered but not analyzed in detail because the Forest Plan does allow road access for all potential project activities, including mineral development, within the Study Area. To require helicopter use would then be considered an unreasonable demand, as helicopter access would not be required of all potential users.

Use of directional drilling was proposed as an alternative method to reduce miles of access road and numbers of well pads. This alternative was considered but not analyzed in detail because, again, the Forest Plan does allow road access for potential project activities and gas-bearing coals increase the technical difficulty and costs of directional drilling to achieve required well spacing.

Two additional methods for the disposal of produced wastewater were proposed as alternatives to deep well disposal. These methods were (1) evaporation and percolation, and (2) discharge to surface water.

Use of lined evaporation pits is appropriate only under proper climatic conditions; specifically, where the local evaporation rates meet or exceed the volume of water to be disposed. Unlined percolation pits are used when underlying ground water is either unusable or nonexistent. Use of the two alternative methods were not considered feasible because the above environmental conditions are not met.

The discharge of produced water to surface water is regulated under the National Pollutant Discharge Eliminator System. These discharges are only allowable if they meet allowable limits. Surface discharge of produced water was not considered feasible because the concentrations of total dissolved solids in the produced water preclude surface water discharge without incurring significant treatment costs. Treatment of water to reduce total dissolved solids was considered impractical based on investment and operating costs as compared to trucking in this area.

2.6 SUMMARY COMPARISON OF ALTERNATIVES

Table 2-3 provides a data summary of surface disturbance which would result from implementation of one of the three alternatives.

TABLE 2-3

SUMMARY COMPARISON OF ALTERNATIVES

Facilities	Alternatives A	Alternatives B	Alternatives C
On-NFS Lands			
Wells			
Existing Wells (#/acreage)	21[1]/45[2]	21	21
Proposed Wells (#/acreage)	0/0	28/84	95/285
Roads/Flowlines			
Existing FS Roads (mi/acreage)	71/135	71/135	71/135
Proposed Roads/Flowlines ROWs (mi/acreage)	0/0	23/141	52/315
Proposed Flowlines ROWs (mi/acreage)	19/46	19/46	19/46
Produced Water Disposal Wells			
Existing Wells (#/acreage)	0/0	0/0	0/0
Proposed Wells (#/acreage)	0/0	0/0	0/0
Compressor Stations			
Existing Stations (#)	0	0	0
Proposed Stations (#)	0	1	1
Off-NFS Lands			
Wells			
Existing Wells (#/acreage)	22/66	22/66	22/66
Proposed Wells (#/acreage)	0/0	6/18	21/63
Roads/Flowlines			
Proposed Roads/Flowlines ROWs (mi/acreage)	0/0	4.5/27[3]	20.5/124[3,4]
Proposed Flowlines ROWs (mi/acreage)	6.5/16	6.5/16	6.5/16

TABLE 2-3
(Continued)

Facilities	Alternatives A	B	C
Produced Water Disposal Wells			
Existing Wells (#/acreage)	2/6	2/6	2/6
Proposed Wells (#/acreage)	0/0	0/0	0/0
Compressor Stations			
Existing Stations (#/acreage)	1/3	1/3	1/3
Proposed Stations (#/acreage)	0/0	0/0	1/3

[1] The Pine River 2-29 coalbed methane well and the Spring Creek 2-29 conventional gas well occupy the same well pad.

[2] Well access road disturbance included in well total; total disturbance for the roads of the 21 well locations on NFS land is approximately 5.8 acres.

[3] Mileage and acreage figures are based on a projected length of 0.75 miles of 50-foot wide transportation ROW per well on private property.

[4] Mileage and acreage figures include 0.25 mile of access road for second compressor station which would occupy a unique site.

The existing physical, biological, and socioeconomic conditions of the area to be affected by Amoco's proposed actions and alternatives are described in this chapter of the draft EIS. The descriptions of much of the physical and biological elements focus on the EIS Study Area (Figure 1-2), where most of the direct effects from coalbed methane (CBM) gas field development and operations would occur. Discussions of socioeconomic conditions, and to an extent, environmental resources/disciplines including water resources, air quality, and wildlife address baseline conditions over an extended, regional area surrounding the Study Area. Resources/disciplines to be addressed in this assessment are as follows:

Soils and Geologic Hazards	Cultural Resources
Water Resources	Land Use
Meteorology and Air Quality	Transportation
Vegetation, Timber, and Grazing	Noise
Wildlife and Fisheries	Recreational Resources
Visual Resources	Socioeconomic Conditions

The content of the resource/discipline descriptions in this chapter has been guided by the issues and concerns identified during the scoping process (see Section 1.6). Length and level of detail presented for each resource/discipline reflects the sensitivity of the resource to anticipated impacts from implementation of the proposed action or one of the alternatives. The defined sensitivity of each resource/discipline is established, where appropriate, in Section 4.0 - Environmental Consequences.

3.1 SOILS AND GEOLOGIC HAZARDS

Soils of the Study Area occupy terrain dominated mostly by mountainous and hilly features (United States Geological Study (USGS) 1968a, 1968b, 1968c, 1964a, 1964b). Several mesas occur in the western half of the Study Area. The mountains and hills are dissected by V-shaped valleys of streams. These streams drain east or west away from the north-south trending highlands toward the Piedra River valley to the east and the Los Piños River valley to the west. The drainage bottoms of the westerly flowing perennial and intermittent streams broaden into wider valleys and alluvial plains as they approach the western Study Area boundary.

Soils are forming in residuum, colluvium, alluvium, and, to a lesser extent, eolian materials derived from the interbedded sandstones and shales of the Animas and San Jose Formations (United States Department of Agriculture Soil Conservation Service, (USDA SCS 1981; Steven et al. 1974). Strata of the Animas Formation form the more mountainous highlands in the center of the Study Area (Fasset and Hinds 1971, Stevens et al. 1974). Outcrop elevations for this formation range from lows of 7,200 feet in the west and south, increasing to 8,000 feet in the north and to topographic highs of 8,700 feet to 8,900 feet (Pargin Mountain elevation, 8,936 feet)(USGS 1968a, 1968b, 1968c, 1964a, 1964b). Strata of the San Jose Formation form the hills and mesas at elevations below the base of the Animas Formation (Fasset and Hinds 1971; Stevens et al. 1974). Quaternary/alluvial deposits cover the broad alluvial valleys of the major creeks and the Piedra River bottom within the Study Area (Stevens et al. 1974). Elevations in the Study Area range from lows of approximately 6,300 feet in the Piedra River valley, 6,700 feet in the Spring Creek valley, and 6,900 feet in the Beaver Creek valley to over 8,900 feet in the central mountains (USGS 1968a, 1968b, 1968c, 1964a, 1964b).

The published Soil Survey of the Piedra Area, Colorado, in the general mapping unit descriptions, describes the soils of the Study Area as being shallow (less than 20 inches deep) to deep (greater than 40 inches deep), well drained, fine textured to medium textured soils that formed in those materials derived from interbedded sandstone and shale (Forest Service (FS) and SCS 1981). Soil development ranges from little horizon differentiation on land surfaces of recent age to well developed subsoils on older land surfaces.

3.1.1 Soils

The Soil Survey of the Piedra Area, Colorado (FS and SCS 1981) provides detailed soil unit mapping and associated mapping unit descriptions and interpretations of unit-specific parameters. The detailed soils mapping and descriptions were checked in the field to verify their useability. A few discrepancies were found. However, none significantly affected the interpretations regarding soil characteristics or boundary delineations. The soils mapping (detailed Order III, minimum acreage of soil map units range from 1.5 to 10 acres) of the Study Area is presented on the maps of the published soil survey (FS and SCS 1981).

The dominant soils of the Study Area are upland soils which occupy the ridge, mesa tops, side slopes, canyon sides, and rolling hills of the HD Mountains (FS and SCS 1981). These soils occupy approximately 80 percent of the Study Area and approximately 87 percent of the National Forest System (NFS) land within the Study Area. The principal upland soils are the Carracas and Corta soils (FS and SCS 1981). Additional upland soils are the Chris, Dunton, Mayoworth, and Greenough soils. Soil development of the mostly loamy upland soils

range from poorly developed soils on steep, exposed surfaces to well developed soils on less steep, vegetation surfaces. The significant presence of areas of rock outcrop and eroded badlands within the Study Area is indicative of the steepness and lengths of slopes and the high erodibility of the area's soils.

The lowland soils of the valley toe-slopes and fans, alluvial plains and piedmonts, drainage bottoms, and stream terraces are deep, loamy soils which occupy slopes of mostly less than 15 percent (FS and SCS 1981). These soils occupy the remaining 20 percent of the Study Area and 13 percent of the NFS land within the Study Area. The Nunn soils are the dominant lowland soils. Additional lowland soils are the Heflin, Hunchback, and Pescar soils. None of the lowland soils are wetland soils.

A listing of soil characteristics for the soil mapping units of the soils identified above is presented in Table 3-1. Listed characteristics are pertinent to the interpretation of potentially limiting or sensitivity factors. The definition of whether or not a soil characteristic is limiting or sensitive to disturbance is based on conclusions provided in the mapping unit descriptions, the interpretative tables in the soil survey (FS and SCS 1981), and/or the FS and SCS criteria presented in Appendixes C-1 and C-2.

A comparison of values presented in Table 3-1 with Appendixes C-1 and C-2 indicate that potentials for the reclamation and revegetation of most of the soils are fair to good. Exceptions are the Carracas soils which are shallow, have low available water capacity, and in some areas occupy slopes in excess of 40 percent. Badlands and Sandstone Rock outcrop-Ustorthents units have little if any soil cover in most areas and slopes again can exceed 40 percent. Hunchback soils have high shrink-swell potentials.

Revegetation potential is also greatly limited in areas currently undergoing severe erosion and soil loss. These areas are identified below in the discussion of geologic hazards. Areas of Chris, Corta, and Mayoworth soils also occupy areas where slopes exceed 40 percent.

TABLE 3-1

SOIL MAP UNIT CHARACTERISTICS AND INTERPRETATIONS
FOR THE HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT
EIS STUDY AREA

Soil Map Unit	Physiographic Location	Parent Material	Depth Class[1]	Drainage Class	Available Water Capacity	Shrink-Swell Potential	Runoff	K Factor[2]	Water Erosion Hazard	Wind Erodibility Group	Wind Erosion Hazard	T Factor[3]
Badland	Steep to extremely steep, deeply dissected, barren slopes	Exposed shale (sh)	–	–	–	–	Very Rapid	–	–	5	High	–
Carracas loam, 4-25% slopes	Ridge tops and mesa	Residuum of interbedded sandstones (ss) and sh	Shallow	Well	Low	Low	Medium	0.2	Moderate	5	Low	1
Carracas loam, 25-65% slopes	Valley, canyon sides and scarp slopes	Residuum and alluvium of ss	Shallow	Well	Low	Low	Very Rapid	0.2	High	5	Low	1
Chris gravelly loam, 25-65% slopes	Mesas	Residuum of interbedded ss and sh	Deep	Well	Moderate	Low	Rapid	0.24	Moderate	5	Low	3
Corta silt loam, 4-25% slopes	Mesas	Residuum of interbedded ss and sh	Deep									
Corta silt loam, 25-65% slopes	Canyon sides	Residuum and alluvium of ss	Deep	Well	Moderate	Low	Rapid	0.24	Moderate	5	Low	3
Dunton loam 4-25% slopes	Mesa and cuesta dip-slopes	Residuum of ss	Moderately Deep	Well	Moderate	Low	Medium	0.32	Moderate	5	Low	2
Dunton stoney loam, 4-25% slopes	Mesa and cuesta dip-slopes	Residuum of ss	Moderately Deep	Well	Moderate	Low	Medium	0.32	Moderate	5	Low	2
Greenough loam, 4-25% slopes	Low, rolling hills	Loess over ss and sh	Deep	Well	High	Low	Slow-Medium	0.37	Moderate	5	Low	3
Heflin sandy loam, 4-25% slopes	Valley toe-slopes	Alluvium of mostly ss and some sh	Deep	Well	High	Low	Slow	0.32	Moderate	3	High	3

TABLE 3-1
(CONTINUED)

Soil Map Unit	Physiographic Location	Parent Material	Depth Class[1]	Drainage Class	Available Water Capacity	Shrink-Swell Potential	Runoff	K Factor[2]	Water Erosion Hazard	Wind Erodibility Group	Wind Erosion Hazard	T Factor[3]
Hunchback clay loam, 0-4% slopes	Swales, basins, concave drainage ways	Alluvium and colluvium of mixed origin	Deep	Somewhat Poorly	High	High	Slow	0.32	Low	6	Low	5
Hunchback clay loam, 4-15% slopes	Fans and toe-slopes	Alluvium and colluvium of mixed origin	Deep	Somewhat Poorly	High	High	Medium	0.32	Low-Moderate	6	Low	5
Mayoworth silt loam, 25-65% slopes	Mesas, scarp slopes, valley sides	Residuum of sh and sandy sh	Moderately Deep	Well	Moderate	Low	Medium	0.37	High	5	Low	2
Nunn loam, 0-4% slopes	Alluvial plains and piedmonts	Alluvium of sh and some ss	Deep	Well	Moderate	Moderate	Slow	0.24	Moderate	5	Low	5
Nunn loam, 4-25% slopes	Alluvial plains and piedmonts	Alluvium of sh and some ss	Deep	Well	Moderate	Moderate	Slow	0.24	Moderate	5	Low	5
Pescar loam, 0-8% slopes	Terraces of major streams	Alluvium of mixed origin	Deep	Somewhat Poorly	Moderate	Low	Slow	0.28	Low	5	Low	5
Riverwash	River bottom	Water worn sand, gravel, cobbles	–	–	–	–	–	–	–	–	–	–
SS Rock Outcrop - Ustorthents	Cliffs, dip-slopes, scarps	Exposed ss	–	–	–	–	–	–	–	–	–	–

[1] Shallow - Depth to bedrock is 0 to 20 inches
Moderately Deep - Depth to bedrock is 20 to 40 inches
Deep - Depth to bedrock is 40 to 60 inches

[2] Soil erodibility factor for surface horizon

[3] Maximum average annual rate of soil loss in tons/acre that can be tolerated without affecting productivity over a sustained period

Source: USDA SCS and USFS 1981.

The water erosion hazard is high for areas of Carracas, Chris, Corta, and Mayoworth soils which occupy slopes ranging from 25 to 65 percent (Table 3-1). The steepness of the slopes and the loamy texture of these soils contribute significantly to their high potential erodibility. Further definition of areas with steep slopes is provided below.

3.1.2 Slopes

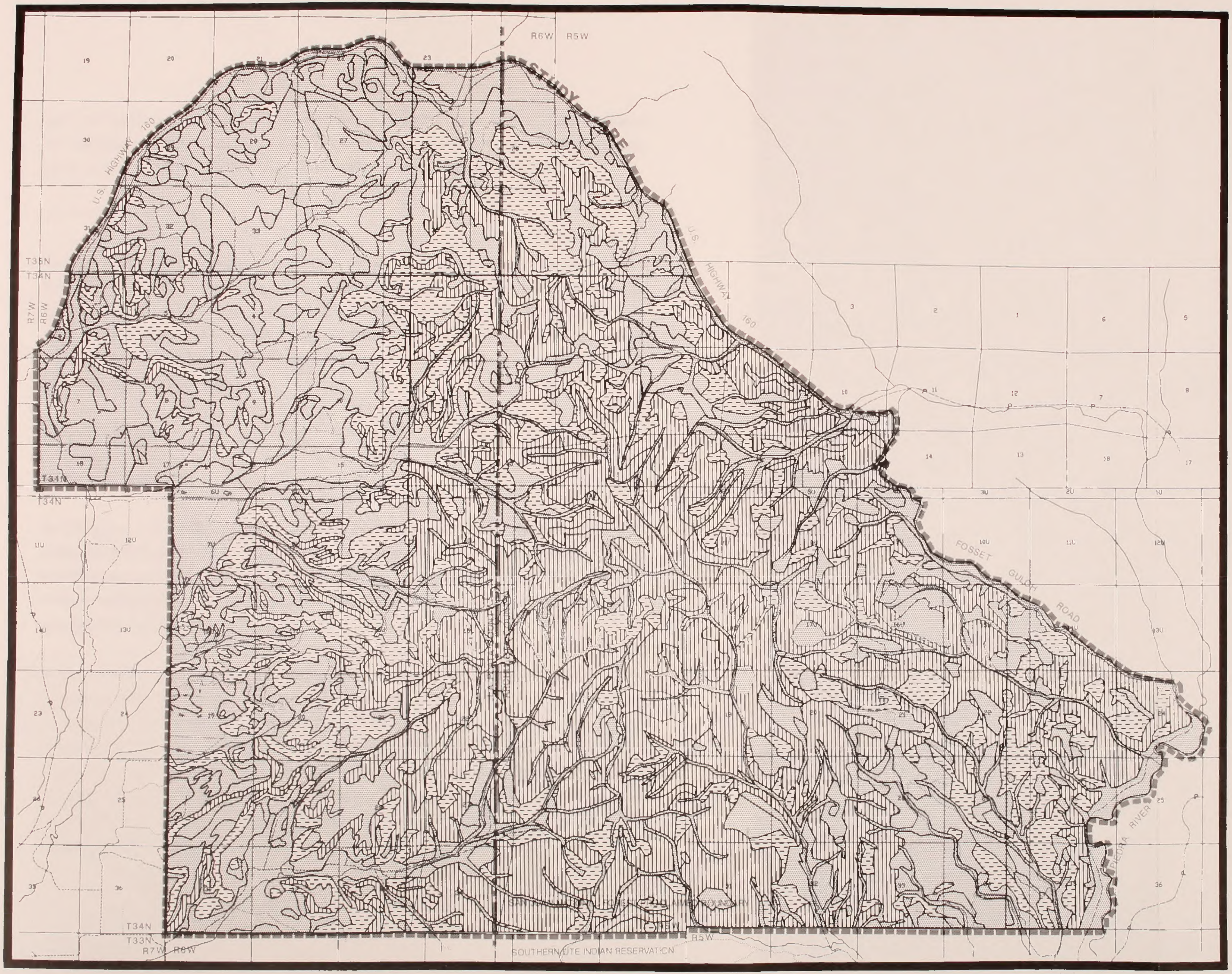
Definition of slopes within the Study Area beyond the level of detail presented in the referenced soil survey (FS and SCS 1981) is provided in Figure 3-1. Slope units are composed of ranges of 0 to 25; 25 to 40; and 40 to greater than 60 percent slopes. These ranges were established based on limits applicable to defining limitations pertinent to the construction and operation of natural gas well fields (Appendix C-3). Delineations of these slope ranges were developed on the USGS topographic quadrangle maps using a hand scale to group slopes.

Water erosion potential is further defined into areas of high, moderate, and low erosion potential. The erosion potential units have been developed using the slope mapping in Figure 3-1 and the soil erodibility K factor for each soil mapping unit listed in Table 3-1. The methodology and criteria for classifying erodibility are presented in Appendix C-4.

3.1.3 Geologic Hazards

Potential geologic hazards within the Study Area are limited primarily to landslide deposits, areas potentially subject to landslides (Colton et al. 1975), and observed surface instability/erosion. The Study Area contains no known active faults (Kirkham and Rogers 1981). Three earthquakes, each with a magnitude of two or lower, have been recorded outside but within 10 miles of the Study Area (National Oceanic and Atmospheric Administration (NOAA) 1983; Woodward-Clyde Consultants 1986). Liquefaction is not a potential significant hazard due to the lack of seismic activity and saturated soils (NOAA 1983; FS and SCS 1981). Subsidence is not a potential significant hazard due to the lack of subsidence prone geology and man-induced subsidence conditions such as underground mining (Fassett and Hinds 1971).

Known landslide deposits (Bell, personal communication, 1990; Colton et al. 1975) and areas of inferred landslide deposits based on interpretation of stereo-paired aerial photography (August 1989, 1:24,000 scale,



SLOPE

PERCENT SLOPES

- 0-25
- 25-40
- 40+

NOTE: DETAILED MAP SHOWING 0-6,6-15,15-25,25-40, 40-60, AND 60+ IS LOCATED IN THE PROJECT FILE

SOURCE: USGS QUADS

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE **3-1**

color aerial photography) are identified for the Study Area in Figure 3-2. Observed areas of high soil erosion and instability are also identified in Figure 3-2. Moderate to high geologic and soil instability is generally associated with topographic features of exposed Animas Formation strata (Colton et al. 1975).

3.2 WATER RESOURCES

The proposed HD Mountains coalbed methane project is located in the central portion of the San Juan River Basin in Colorado. The San Juan Basin is an asymmetric structural depression in northwestern New Mexico and southwestern Colorado. It drains approximately 5,800 square miles in Colorado, with nine main tributary streams draining the Colorado portion of the San Juan Basin. In downstream order they are the San Juan, Piedra, Los Piños, Florida, Animas, La Plata, Mancos, Dolores, and McElmo Creek. This section is divided into surface water and ground water.

3.2.1 Surface Water

Surface Water Resources

The Study Area is drained by two primary rivers: the Piedra and the Los Piños. The Piedra River flows predominantly south and enters into the Navajo Reservoir just north of the Colorado-New Mexico border. The Los Piños starts out flowing southwest and then turns south and enters the Navajo Reservoir about 10 miles south of the Colorado-New Mexico border. The major tributaries of these two river systems within the proposed Study Area are shown on Figure 3-3.

A ridge running north-south, approximately 1 to 1.5 miles east of the La Plata-Archuleta County line, divides the Study Areas into the two drainage systems. The surface water flow east of this ridge is east-southeast into the Piedra River and encompasses approximately 36 square miles. The surface water flow west of the ridge is predominantly west-southwest within the Study Area but changes abruptly to the south-southwest just outside the area, and comprises about 54 square miles in the Study Area. Elevation of the Study Area varies from 8,936 feet at Pargin Mountain along the north-south ridge to 6,400 feet at the confluence of Bull Creek, with the Piedra River on the east, and 6,890 feet at Harper Pond on Ute Creek to the west. Slope aspects and gradients are highly variable in the area.

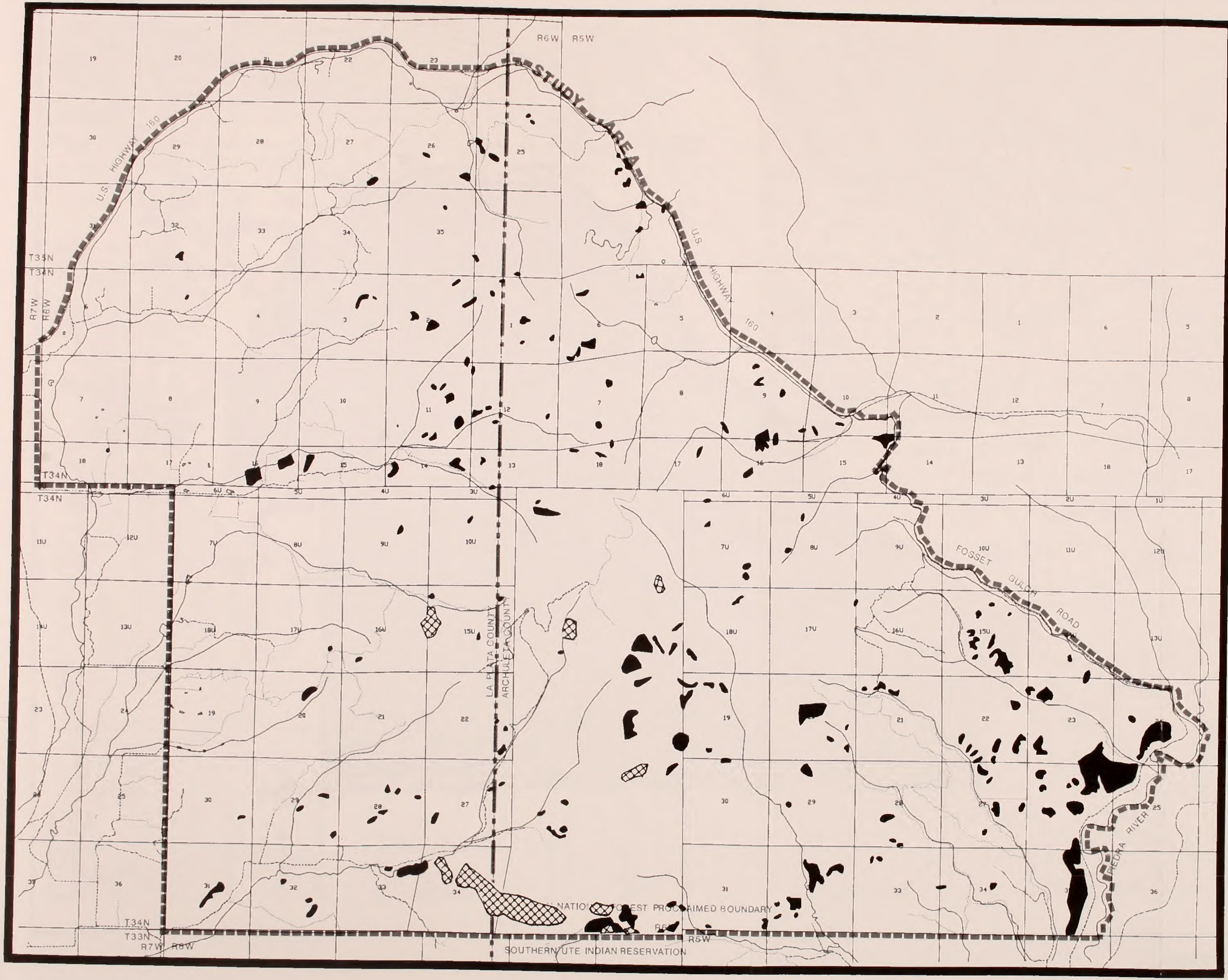
By using the soil survey (FS and SCS 1981), it is possible to compare present substrate composition in the river channel with substrate composition in the adjacent floodplains. These floodplains are underlain by alluvial deposits of river wash sediment. The present river course and the presence of river wash soils out of the present channel indicate the instability of the river.

The one-hundred-year floodplain was delineated for the Piedra River by the National Flood Insurance Program (now FEMA) in 1979. These floodplains vary in width from a minimum of approximately 200 feet just upstream of the confluence with Bull Creek Pond and a maximum width of approximately 1,500 feet at the confluence of Devil Creek. Floodplain soils usually consist of the aforementioned riverwash or Pescar soils. The Pescar soils consist of somewhat poorly drained soils found in alluvium. For a more detailed discussion of soils, see Section 3.1.

Average annual precipitation is approximately 15 to 25 inches over most of the Study Area, with the majority occurring in the form of snow. Snowfall accumulates from November through April, with maximum accumulations typically occurring in April. Annual snowfall ranges from 60 to 200 inches depending on specific site location and elevation.

The rivers and streams within the Study Area are not continuously gauged. However, four streams (Yellowjacket Creek, Fosset Gulch, Turkey Creek, and Beaver Creek) were measured for instantaneous flows in 1984 and ranged between 0.255 and 18.5 cubic feet per second (cfs) (Table 3-2). Both the Piedra and Los Piños rivers have two USGS continuous flow monitoring gauges (operated both upstream and downstream of the Study Area). There is also a continuous USGS gauge on Spring Creek, located downstream of the Study Area. Data for these stream gauge locations are also summarized in Table 3-2. In general, flows in the Piedra River increase downstream while flows on the Los Piños decrease downstream. There are several irrigation diversions below the Vallecito Reservoir which account for this decrease. Peak runoff for these streams occurs between April and June, with low flows occurring during December and January. In the winter months, low temperatures preclude any surface runoff so flows during this period are contributed by tributary floodplain alluvial aquifers.

Primary uses of the surface water resources in the Study Area are recreation, wildlife and fish habitat, agriculture, and water supply. There are several irrigation diversions above the town of Piedra on the Piedra River and below Vallecito Reservoir on the Los Piños River. Table 3-3 lists the State of Colorado use



GEOLOGIC HAZARDS

LANDSLIDE DEPOSITS AND POTENTIAL LANDSLIDE AREAS

SEVERELY ERODED LANDS

SOURCE: BELL 1990, COLTON et al. 1975

NORTH

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

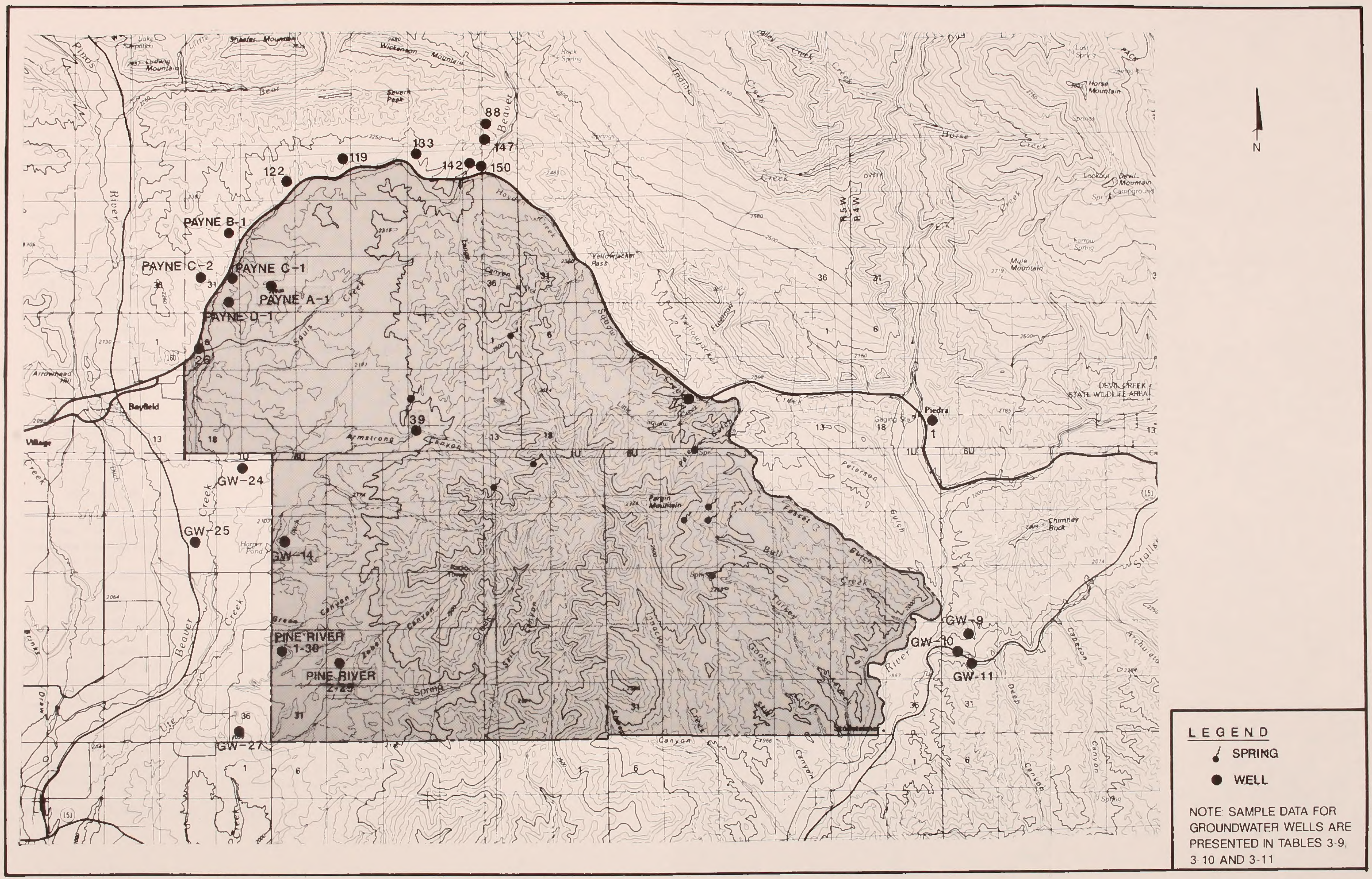
ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 3-2



SPRINGS AND SAMPLED GROUND WATER WELLS
HD MOUNTAINS COALBED METHANE GAS FIELD
DEVELOPMENT EIS STUDY AREA
Figure 3-3

TABLE 3-2

SUMMARY OF SURFACE WATER FLOWS FOR
RIVERS IN THE VICINITY OF THE HD MOUNTAINS
COALBED METHANE GAS FIELD DEVELOPMENT EIS STUDY AREA
(Listed in Downstream Order within a Primary River)

	Stream Flow (cfs)				
	Mean	Minimum	Maximum	Sampling 7Q10[1]	Dates
Piedra River (at Piedra)	311	17	5180	28.2	1939-1973
Piedra River (at Arboles)	396	20	5360		1962-1985
Squaw Creek					
Little Squaw Creek					
Yellowjacket Creek	1.2	1.0	1.5		1984[2]
Fremont Creek					
Pole Gulch					
Fosset Gulch	0.25	0.2	0.3		1984[3]
Peterson Gulch					
Bull Creek					
Turkey Creek	0.85	0.8	0.9		1984[4]
Goose Creek					
Skull Canyon					
Ignacio Creek					
Sheep Canyon					
Los Pinos River (at Bayfield)	358	0	4030		1927-1985
Los Pinos River (at La Boca)	230	6	4560	22.2	1951-1985
Beaver Creek	18.5	13	24		1984[3]
Hayden Creek					
Lange Canyon					
Sauls Creek					
Armstrong Canyon					
Ute Creek					
Green Canyon					
Spring Creek (at La Boca)	31.5	1.0	778.0		1951-1985
Salt Canyon					
Zabel Canyon					

[1] Lowest means discharge for seven consecutive days at the ten-year recurrence interval
[2] This was a one time instantaneous measurement collected in August, 1984
[3] These were instantaneous measurements collected in April and July, 1984
[4] This was a one time instantaneous measurement collected in April, 1984

Source: USGS Stream Flow Monitoring Program.

TABLE 3-3

STATE OF COLORADO USE CLASSIFICATIONS FOR SURFACE WATER RESOURCES IN THE HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT EIS STUDY AREA

Surface Water Body	Use Classification							
	Recreation		Aquatic Life				Water Supply	Agriculture
			Class 1		Class 2			
	Class 1	Class 2	Cold	Warm	Cold	Warm		
Piedra River	X		X				X	X
Squaw Creek	X		X				X	X
Little Squaw Creek	X		X				X	X
Yellowjacket Creek	X		X				X	X
Freeman Creek	X		X				X	X
Pole Gulch	X		X				X	X
Fosset Gulch		X				X		X
Peterson Gulch		X				X		X
Bull Creek		X				X		X
Turkey Creek		X				X		X
Goose Creek		X				X		X
Skull Canyon		X				X		X
Ignacio Creek		X				X		X
Sheep Canyon		X				X		X
Los Pinos River	X		X				X	X
Beaver Creek	X		X				X	X
Hayden Creek	X		X				X	X

Sheet 1 of 2

TABLE 3-3
(CONTINUED)

Surface Water Body	Use Classification							
	Recreation		Aquatic Life				Water Supply	Agriculture
			Class 1		Class 2			
	Class 1	Class 2	Cold	Warm	Cold	Warm		
Lange Canyon	X		X				X	X
Sauls Creek	X		X				X	X
Armstrong Canyon	X		X				X	X
Ute Creek	X		X				X	X
Harper Pond	X				X			X
Green Canyon	X		X				X	X
Spring Creek	X		X					
Salt Canyon	X		X					
Zabel Canyon	X		X					
San Juan River								
Sambrito Creek		X				X		X

Source: Colorado Water Quality Control Commission 1990.

classifications for the identified surface water resources in the Study Area. Additional detail on use classifications and numeric standards are presented in Appendix C-5.

Surface Water Quality

Surface water quality data have been collected at various times on both the Piedra and Los Piños Rivers. Additionally, occasional water quality measurements have been collected at various tributaries to these rivers. A discussion of these water quality data is presented below.

Tables 3-4 and 3-5 present surface water quality data collected on the Piedra River near Arboles, Colorado by the USGS and Colorado Department of Health. The overall surface water quality is considered good for the Piedra River in this area. The total dissolved solids (TDS) and total suspended solids (TSS) increase uniformly downstream, but do not exceed applicable Colorado and Federal stream standards. Unionized ammonia and phosphorous concentrations have slightly exceeded the proposed cold water biota standards at times in the lower reaches of the Piedra River near the Study Area. Since no significant municipal discharges enter the stream, the probable inputs are agricultural nonpoint sources. Summer temperatures in the lower reaches exceed the cold water fisheries standards. Iron and mercury concentrations near the mouth of the Piedra River also have exceeded stream standards. The reasons for these exceedences are unclear. The river appears slightly degraded downstream of the Study Area, based on the change in biological species and total numbers, as compared to conditions near the river's headwaters.

Water quality data for three tributaries of the Piedra River (Yellowjacket Creek, Fosset Gulch, and Turkey Creek), collected once in 1984, are located in the project file. None of the parameters tested exceeded water quality standards.

Water quality data for the Los Piños River and Spring Creek collected near La Boca, Colorado are shown in Tables 3-6 and 3-7, respectively. The Los Piños River appears to be impacted by man to a greater extent than the Piedra River. These impacts appear to result from extensive irrigation diversions/returns within the basin, five wastewater treatment plant discharges, and water quality changes that occur within the Vallecito Reservoir. Un-ionized ammonia and phosphorous concentrations exceeded the proposed cold water biota standards at certain times at locations below Vallecito Reservoir near the Study Area. This is probably due to wastewater treatment plant discharges and irrigation return flows. Occasionally, temperatures also exceed the standard for cold water fisheries. Iron has been observed at concentrations

TABLE 3-4

WATER QUALITY DATA FROM THE PIEDRA RIVER
NEAR ARBOLES[1], COLORADO
(Collected by the Colorado Department of Health)

Parameter	Mean	Minimum	Maximum	Number of Samples	Sampling Period
Water Temp. (°F)	47.8	31.0	80.0	122	1968-1987
Conductivity (µmhos/cm @ 25°C)	309	110	560	112	1968-1987
Total Alkalinity (mg/ℓ of $CaCO_3$)	85.7	32	136	111	1968-1987
Total Hardness (mg/ℓ of $CaCO_3$)	139.3	47	277	91	1968-1987
Dissolved Solids (mg/ℓ @ 180°C)	113.4	0	3,600	73	1968-1987
Turbidity (NTU)	50.8	0.8	525.0	65	1968-1980
Dissolved Oxygen	10.01	6.7	13.9	81	1973-1987
Biochemical Oxygen Demand (5-day)	1.41	0.6	3.0	64	1968-1987
Chloride (mg/l)	6.0	2.0	11.0	64	1968-1980
Total Phosphorus (mg/l)				37	1974-1987
Total Nitrogen as: NO_2 + NO_3 (Nitrite + Nitrate)	0.457	0.05	0.57	49	1979-1987
Total Nitrogen as: NH_3 + NH_4 (Unionized + ionized ammonia)	0.103	0.00	0.710	59	1968-1982

[1] Three miles downstream from confluence with Ignacio Creek.

Source: U.S. EPA 1987.

TABLE 3-5

WATER QUALITY DATA FROM THE PIEDRA RIVER
NEAR ARBOLES[1], COLORADO
(Collected by USGS)

Parameter	Mean	Minimum	Maximum	Number of Samples	Sampling Period
Water Temp. (°F)	49.8	32.0	80.6	106	1969-1984
Conductivity (μmhos/cm @ 25°C)	287	96	560	85	1969-1984
Total Alkalinity (mg/ℓ of $CaCO_3$)	86	50	130	11	1969-1973
Total Hardness (mg/ℓ of $CaCO_3$)	115	58	190	11	1969-1973
Dissolved Solids (mg/ℓ @ 180°C)	180	106	292	11	1969-1973
Turbidity (NTU)	99	3	900	11	1970-1973
Dissolved Oxygen	9.4	6.9	11.6	18	1969-1973
Biochemical Oxygen Demand (5-day)	1.6	0.2	3.3	6	1969-1972
Chloride (mg/l)	2.7	1.0	7.0	11	1969-1973
Total Phosphorus (mg/l)	0.102	0.030	0.250	5	1971-1973
Total Nitrogen as: NO_2 + NO_3 (Nitrite + Nitrate)	0.17	0.17	0.17	1	1973
Total Nitrogen as: NH_3 + NH_4 (Unionized + ionized ammonia)	0.115	0.070	0.160	2	1972-1973

[1] Three miles downstream from confluence with Ignacio Creek.

Source: U.S. EPA 1987.

TABLE 3-6

WATER QUALITY DATA FROM THE LOS PINOS RIVER NEAR LA BOCA[1], COLORADO

Parameter	Mean	Minimum	Maximum	Number of Samples	Sampling Period
Water Temp. (°F)	49.7	32.0	82.0	121	1968-1987
Conductivity (μmhos/cm @ 25°C)	230	120	380	110	1968-1987
Total Alkalinity (mg/ℓ of $CaCO_3$)	88	44	150	47	1978-1987
Total Hardness (mg/ℓ of $CaCO_3$)	102	59	178	89	1968-1987
Dissolved Solids (mg/ℓ @ 180°C)	78	0	1,301	92	1968-1987
Turbidity (NTU)	61.2	2.9	430.0	62	1968-1980
Dissolved Oxygen	9.6	6.8	13.8	79	1973-1987
Biochemical Oxygen Demand (5-day)	1.9	0.6	9.0	65	1968-1987
Chloride (mg/l)	6	2	13	60	1968-1980
Total Phosphorus (mg/l)	0.085	<0.001	1.00	72	1974-1987
Total Nitrogen as: NO_2 + NO_3 (Nitrite + Nitrate)	0.54	0.05	2.70	51	1979-1987
Total Nitrogen as: NH_3 + NH_4 (Unionized + ionized ammonia)	0.117	<0.001	1.00	103	1968-1987

[1] At Denver and Rio Grande Railroad Bridge

Source: USEPA STORET water quality data base

TABLE 3-7

WATER QUALITY DATA FROM SPRING CREEK
NEAR LA BOCA[1], COLORADO
LA PLATA COUNTY

Parameter	Mean	Minimum	Maximum	Number of Samples	Sampling Period
Water Temp. (°F)	50.8	32.0	82.4	80	1958-1984
Conductivity (μmhos/cm @ 25°C)	607	228	1,490	58	1958-1984
Total Alkalinity (mg/ℓ of $CaCO_3$)	116	98	134	2	1973-1974
Total Hardness (mg/ℓ of $CaCO_3$)	120	110	130	2	1973-1974
Dissolved Solids (mg/ℓ @ 180°C)	218	218	218	1	1973
Turbidity (NTU)	–[2]	–	–	–	–
Dissolved Oxygen	–	–	–	–	–
Biochemical Oxygen Demand (5-day)	–	–	–	–	–
Chloride (mg/l)	6.55	4.0	9.0	2	1973-1974
Total Phosphorus (mg/l)	0.04	0.04	0.04	1	1973
Total Nitrogen as: NO_2 + NO_3 (Nitrite + Nitrate)	0.01	0.01	0.01	1	1973
Total Nitrogen as: NH_3 + NH_4 (Unionized + ionized ammonia)	0.05	0.05	0.05	1	1973

[1] 0.2 miles upstream from mouth of creek

[2] – refers to no data collected

Source: U.S. EPA 1987.

higher than the proposed cold water biota standard near the mouth of the river. A comparison of the biological quality of the Los Piños River above Vallecito Reservoir with the reach near its mouth reveals that some degradation appears to have occurred. This is indicated by the presence of pollution tolerant organisms and a poor species diversity at the downstream locations.

Water quality data collected in 1984 for three tributaries to the Los Piños River (Beaver Creek, Ute Creek, and Spring Creek below Zabel Canyon) are located in the project file. None of the parameters tested exceeded applicable stream water quality standards.

The majority of the pollution entering the surface waters in and around the Study Area comes from agricultural nonpoint sources and from either of the tributary streams during flow events. Along the Piedra River and its tributaries within the Study Area, there is a low sediment yield of 0.1 to 0.2 acre-feet (340 to 850 tons)/mi^2/year. In addition, there is a low potential for inflow, a low potential for saline runoff waters, and a low potential for sources of nitrite and ammonia from irrigation return flows. Along the Los Piños River and its tributaries, the sediment yield ranges from a moderate 0.2 to 0.5 acre-feet (850 to 1,700 tons)/mi^2/year in most of the drainage area to a high of 0.5 to 1.0 acre-feet (1,700 to 3,700 tons)/mi^2/year in the area between Armstrong and Green Canyons. There is a low to moderate potential for input of saline runoff waters, particularly along Ute and Beaver Creeks. The potential for sources of nitrite and ammonia is low to moderate due to more extensive irrigation diversions and return flows. Located just south of the Study Area is the Southern Ute Indian Reservation. This area has very high erosion and high sediment yield potential, as well as moderate potential for sources of saline runoff waters. The major point sources of pollution come from the five wastewater treatment plants along the Los Piños River (with the one at Bayfield being the closest to the Study Area), from several campgrounds along Vallecito Reservoir, and from residential septic systems along the river above and below Vallecito Reservoir.

Coal bed methane development has occurred since 1985 in the Study Area. Since this time, water quality data appear to indicate that the existing well pads, roads, and flowlines have had a negligible longterm impact on surface water quality.

3.2.2 Ground Water

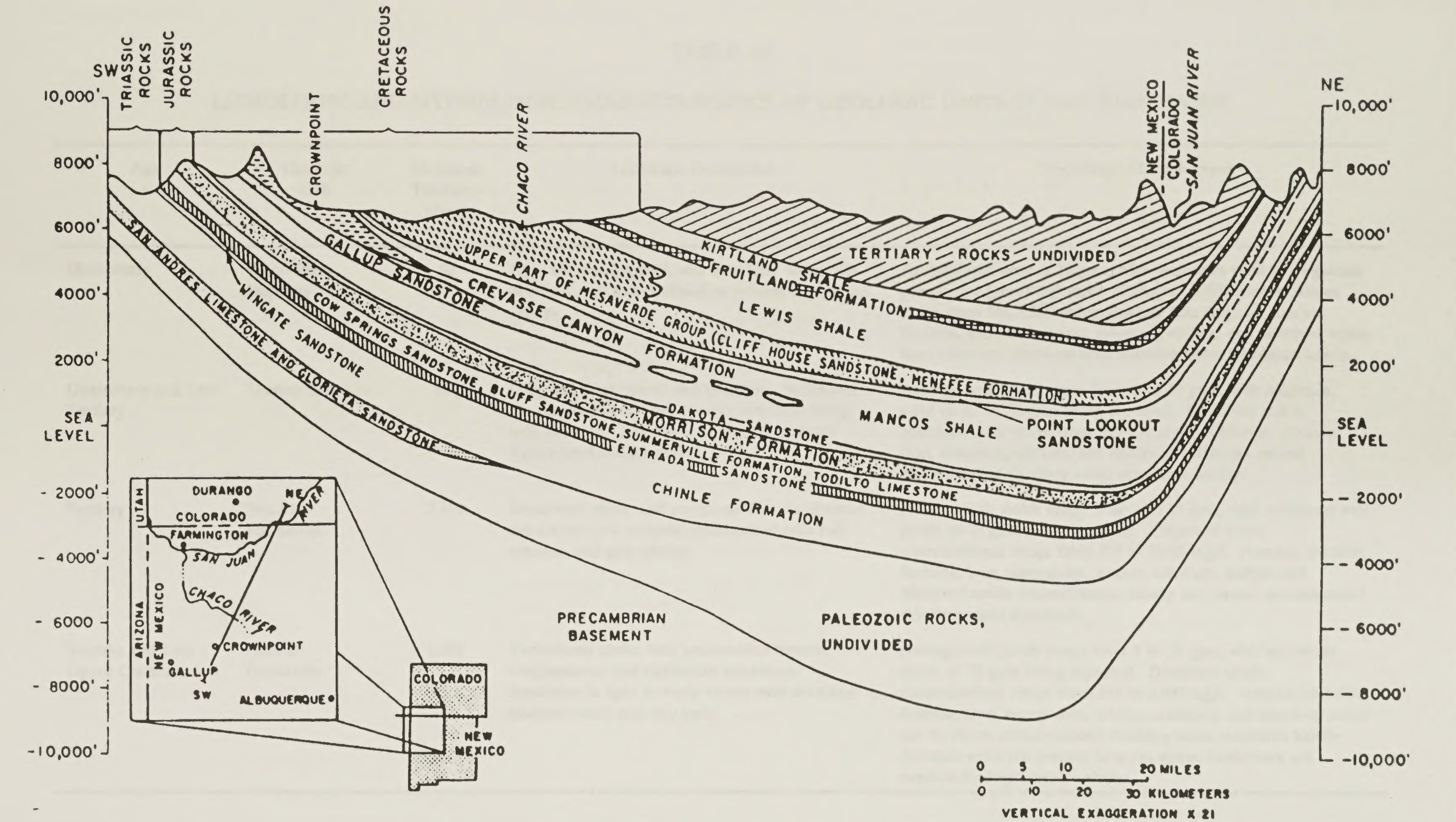
In order to describe the ground water resources in the Study Area, information is presented in the following sub-sections on geology, petroleum reservoir characteristics, ground water resources, and ground water quality. Given the interdependencies of these topics, there is some intermixing of information between sub-sections.

Geology

Geologic units in the San Juan Basin range from Cambrian to Quaternary in age. Figure 3-4 is a northeast trending stratigraphic cross-section of upper Cretaceous rocks in the San Juan Basin. The northern portion of the cross-section is a generalized vertical presentation of the stratigraphy in the Study Area. (Steven et al. 1974; Brogden et al. 1979). Relative to the proposed project, the geologic units of Cretaceous age are of primary importance, specifically the Fruitland Formation. Stratigraphically, the Cretaceous age Dakota Sandstone is overlain by the Mancos Shale, Point Lookout Sandstone, Menefee Formation, Cliffhouse Sandstone, Lewis Shale, Pictured Cliffs Sandstone, and the Fruitland Formation. The Fruitland Formation is overlain by the Kirtland Shale, late Cretaceous and Tertiary aged Animas Formation, and the San Jose Formation of the Tertiary age. Late Tertiary and Quaternary aged Terrace and Alluvial Floodplain deposits overlay the bedrock units. A stratigraphic description of the primary rock units of the Study Area in the San Juan Basin is listed in Table 3-8.

Lithologically, in general, the San Juan Basin bedrock units are shale, fine- to medium-grained sandstone, siltstone, and claystone. These bedrock units are commonly interbedded and lenticular in nature. The terrace deposits consist primarily of well-rounded boulders and gravel. The alluvial floodplain deposits consist of gravel, sand, silt, and clay. East of the La Plata-Archuleta County line, the Fruitland Formation and Kirtland Shale have similar characteristics and are mapped as one unit in this area. The Fruitland Formation is 250 to 300 feet thick in the Study Area, and the basal coal beds, where the majority of coal and methane production occurs, are at depths in excess of 1,500 feet. The Lower Fruitland Formation is intertongued with the upper Pictured Cliffs Sandstone and is differentiated from the lower Kirtland Shale by the presence of carbonaceous shale and coal seams. The Fruitland Formation coals and carbonaceous shales are the result of deposition in fresh water lagoons, swamps, marshes and/or abandoned channels during the final regression of the Upper Cretaceous Sea from the San Juan Basin (Fassett and Hinds 1971; Kelso and Wicks 1988). Coal has been mined locally along the outcrop areas of the Fruitland Formation east and west of the Study Area (Brodgen et al. 1979).

The bedrock units crop out along the northern margin of the San Juan Basin, approximately one to two miles north of the Study Area forming the Hogback Monocline. Near the basin margin, the bedrock units



GENERALIZED GEOLOGIC SECTION OF THE SAN JUAN BASIN

Figure 3-4

TABLE 3-8

LITHOLOGIC AND HYDROLOGIC CHARACTERISTICS OF GEOLOGIC UNITS IN SAN JUAN BASIN[1]

Age	Geologic Unit	Maximum Thickness (feet)	Lithologic Description	Hydrologic Characteristics
Quaternary	Flood-Plain Deposits	50	Clay, silt, sand, gravel, and boulders. Generally poorly sorted and confined to present day stream valleys.	Average well yield is 10 gpm, with maximum yield of 25 gallons per minute (gpm) reported. Dissolved solids concentrations range from 148-5,390 milligrams per liter (mg/l). Arsenic, fluoride, iron, manganese, selenium, sulfate, and dissolved solids have exceeded recommended drinking water standards locally.
Quaternary and Late Tertiary	Terrace Deposits	100	Clay, silt, sand, gravel and boulders. Sediments are poorly sorted, with coarser materials being well rounded. Remnants of alluvial fans and higher level stream valleys.	Average well yields range from 5 to 10 gpm, with maximum yield of up to 50 gpm being reported. Dissolved solids concentrations range from 205-870 mg/l. Chloride, fluoride, iron, selenium, sulfides, and dissolved solids can exceed recommended drinking water standards locally.
Tertiary	San Jose Formation	2,500	Sandstone, shale, and conglomerate. Sandstones are arkosic and massive, interbedded with red, maroon, and gray shales.	Average well yields range from 1 to 10 gpm, with maximum well yields of 75 gpm being reported. Dissolved solids concentrations range from 117 to 2,910 mg/l. Arsenic, chloride, fluoride, iron, manganese, nitrate, selenium, sulfate and dissolved solids concentrations locally can exceed recommended drinking water standards.
Tertiary and Late Upper Cretaceous	Animas Formation	1,400	Varicolored shale, with interbedded breccia, conglomerate and tuffaceous sandstone. Sandstone is light to rusty brown with abundant silicified wood and clay balls.	Average well yields range from 1 to 10 gpm, with maximum yields of 75 gpm being reported. Dissolved solids concentrations range from 115 to 3,490 mg/l. Arsenic, chloride, fluoride, iron, manganese, nitrate, selenium, and dissolved solids can be above recommended drinking water standards locally. Artesian wells are present in areas where sandstones are overlain by impermeable shales.

TABLE 3-8
(Continued)

Age	Geologic Unit	Maximum Thickness (feet)	Lithologic Description	Hydrologic Characteristics
Upper Cretaceous	Kirtland Shale	1,200	Interbedded sandstone, shale, and siltstone. Shales are olive to medium gray with varying amounts of silified wood and thin lenses of silty clay and friable sandstone. The middle unit, the Farmington Sandstone Member, is thick to massive, with characteristic crossbedding.	Well yields up to 5 gpm have been reported. Dissolved solids concentrations range from 1,120 to 4,450 mg/l. Arsenic, iron, manganese, and dissolved solids concentrations can locally exceed recommended drinking water standards.
Upper Cretaceous	Fruitland Formation	300	Varying proportions of interbedded sandstone, shale, and coal. The sandstone beds are fine to medium grained; gray, brown and olive in color and grade laterally and vertically into shales and siltstones. Upper sandstone beds are well indurated and form resistant ledges.	Limited well information available. Sandstones in the outcrop area may be aquifers, with well yields being estimated at less than 5 gpm. Water from two springs sampled had dissolved solids concentrations of 3,120 and 3,800 mg/l. Iron, manganese, sulfate and dissolved solid concentration occurred in excess of recommended drinking water standards.
Upper Cretaceous	Picture Cliffs Sandstone	300	Sandstone, light-olive-gray, to grayish-orange and orange, well sorted. Fine-to-medium-grained, medium-to-hick-bedded, and cliff forming. Interbedded with small amounts of shale and siltstone.	Well yields of up to 5 gpm. Dissolved solids concentrations range from 222 to 1,830 mg/l. Fluoride, sulfate, and dissolved solids can locally exceed recommended drinking water standards. Artesian wells may be developed in areas where the sandstone is overlain by impermeable shales.
Upper Cretaceous	Lewis Shale	1,800	Shale, light-to-dark gray and black of Marine origin. Interbedded with light-gray sandstone, sandy to silty limestone and several calcareous concentrations.	Well yields up to 3 gpm. Dissolved solids concentrations range from 427 to 3,370 mg/l. Chloride, iron, nitrate, selenium, sulfate, and dissolved solids concentrations can locally exceed recommended drinking water standards.
Upper Cretaceous	Mesaverde Group Cliff House Sandstone	350	Gray, calcareous, marine sandstone, and silty shale, crossbedded and massive in places.	Well yields up to 5 gpm. Dissolved solids concentrations range from 372-3,500 gpm. Fluoride, iron, manganese, sulfate, and dissolved solids concentrations can locally exceed recommended drinking water standards.
Upper Cretaceous	Menefee Formation	350	Varying proportions of light-gray sandstone, siltstone, and shale, with interbedded coal seams.	Well yields up to 5 gpm. Dissolved solids concentrations range from 1,590 to 7,170 mg/l. Fluoride, iron, sulfate, and dissolved solids concentrations can exceed recommended drinking water standards, locally.

TABLE 3-8
(Continued)

Age	Geologic Unit	Maximum Thickness (feet)	Lithologic Description	Hydrologic Characteristics
Upper Cretaceous	Point Lookout Sandstone	400	Light-gray to brown marine sandstone, massive and cliff forming. Interbedded siltstone and shale in lower part.	No well information available, however, well yields and quality is likely similar to Cliff House Sandstone. Artesian wells may be developed in sandstone where overlain by impermeable shales.
Upper Cretaceous	Mancos Shale	1,900	Dark-gray, silty and sandy marine shale. Some interbedded sandstones and limestone. Lower 200 feet is calcareous and locally fossiliferous.	Yield for 1 well sampled was 1 gpm. Dissolved solids concentration of 1,250 mg/l. Selenium, sulfate, and dissolved solids were in excess of recommended drinking water standards.
Upper and Lower Cretaceous	Dakota Sandstone	200	Sandstone, light-gray to yellowish-brown, with interbedded siltstone black carbonaceous shale, and coal. Many conglomerate lenes near the base.	Well yields reported up to 5 gpm. Dissolved solids concentrations range from 273 to 400 mg/l. Artesian wells may be developed in areas where the sandstone is overlain by impermeable shales.

[1]Source: Brogden et al. 1979.
Steven et al. 1974.

are folded and steeply dip toward the deepest part of the basin, south of the Colorado-New Mexico border (Ayers et al. 1988; Kelso and Wicks 1988; and Steven et al. 1974). Figure 3-5 illustrates the general surface geology of the San Juan Basin in the Study Area. Near the Study Area, the Fruitland Formation and Kirtland Shale crop out approximately one to two miles north of Highway 160, which is north of the project Study Area. Tertiary rocks of the Animas Formation crop out along the west, north, and eastern edges of the Study Area. Rock units of the San Jose Formation crop out in the central portion of the Study Area, along the La Plata-Archuleta County line. The San Jose Formation outcrop extends from the southern boundary to approximately one mile south of the Study Area's north boundary. Quaternary Alluvial Floodplain deposits are present along Beaver Creek, Ute Creek, Sauls Creek, and the Piedra River (Brodgen et al. 1979; Fassett and Hinds 1971; Steven et al. 1974; and Molenaar 1988).

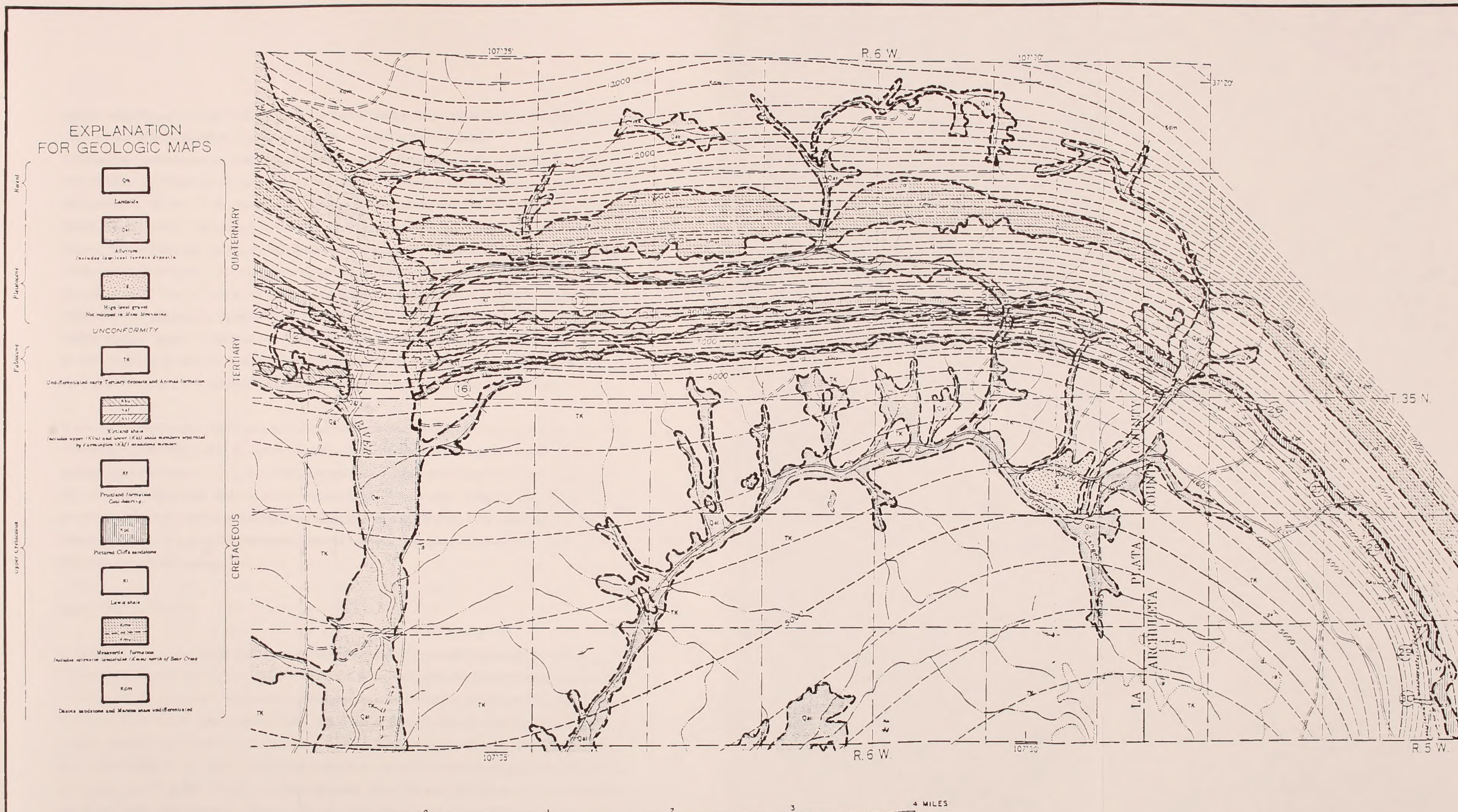
General dip of the rock strata in the Study Area is 10° or less to the south toward the center of the San Juan Basin in northwestern New Mexico (Brooks 1985). In the area north of Bayfield, the dip of rock strata is as great as 55° in the Hogback Monocline area. Toward the center of the San Juan Basin, away from the Hogback Monocline, the dip is relatively flat.

In the San Juan Basin, discontinuous localized faults and fractures occur, primarily along the margins of the San Juan Basin, while within the Central Basin very little faulting or fracturing is present (Fassett and Hinds 1971; Brooks 1985; Kelso and Wicks 1988; and Condon 1988). Folding and uplifting of the Fruitland strata at the basin margins resulted in fractured beds within the Fruitland Formation (Ayers et al. 1988). Some fractures have also been observed in the Kirtland Shale, and the Animas and San Jose Sandstone units in the Hogback Monocline area (Condon 1988). Observations of joints at the surface made during Condon's studies suggest that the major joint patterns along the rim of the San Juan Basin generally parallel the axis of the Hogback Monocline, with other minor joint patterns occurring perpendicular to the major joints. However, no evidence indicating intersection between the major and minor joint patterns was observed (Condon 1988). Joints may possibly extend across bedding planes of the sandstone; however, they do not continue into adjacent shale and/or coal beds even though the shale and coal may be fractured (Condon 1988; Condon, personal communication, 1989). Therefore, even though some discontinuous localized faults/fractures are present primarily along the margins of the San Juan Basin, they do not result in significant hydraulic connection between overlying formations and the Fruitland formations.

Petroleum Reservoir Characteristics

Potentiometric surface values and pressure gradients for the Fruitland Formation have been estimated from shut-in pressures recorded in drill-stem tests and bottom-hole pressures calculated from well-head shut-in pressures (Ayers et al. 1988). These results indicate a potentiometric high in the north portion of the San Juan Basin, which decreases and flattens toward the center of the basin. Bottom-hole pressures in the north-central basin ranged from 1,400 to 1,850 pounds per square inch (psi) (0.44 to 0.63 psi/ft pressure gradient), whereas bottom-hole pressures in the southern portion of the basin range from 400 to 1,000 psi (0.30 to 0.40 psi/ft pressure gradient) (Ayers et al. 1988). This pressure data indicates that within the Study Area the Fruitland Formation is primarily over-pressured (Rice et al. 1988; Ayers 1988a) and extends to within two miles of the northern outcrop (Ayers 1988b; BLM 1989). The coal beds in the Fruitland Formation have higher pressures because gas is hydrostatically retained in the coal's microscopic structure (Rice et al. 1988; BLM 1989). This overpressuring implies the Fruitland Formation is a closed system, which means the formation is confined and not directly hydraulically connected with surrounding formations. The water quality and gas content reservoir characteristics indicate that the Fruitland Formation is a closed reservoir or confined system. The quality of water derived from the Fruitland Coal unit is typically sodium bicarbonate, that appears to be of connate origin and is high in total dissolved solids, as compared to waters of the adjacent Fruitland sandstones (above the coal seam) and Pictured Cliffs Sandstone (below the Fruitland Coal seam) which are sodium chloride type and have lower total dissolved solids concentrations (Rice et al. 1988; Ayers et al. 1988; Decker et al. 1988; McBane 1988). Near the northern outcrop of the Fruitland Formation, formation water is of the Ca-Mg-HCO_3 type, just downdip of the outcrop, the water is of Na-HCO_3 type low in TDS (500 mg/l), whereas waters further down the basin (south of the Study Area) are Na-HCO_3 type but high in TDS (20,000 mg/l) (Ayers et al. 1988). Given the above water types and that the Fruitland Formation water increases in salinity with depth away from the outcrop, strongly suggests a slow moving hydrologic system (1 ft in 30 years) throughout geologic time (perhaps millions of years) in the Fruitland (BLM 1989). Since the Fruitland Formation near the bedrock outcrop receives infiltration from shallow formations, the Fruitland Formation water may be a combination of connate and meteoric waters.

The type of gas produced from the Fruitland Coal units has lower C_2+ hydrocarbon composition as compared to gas produced from adjacent sandstones within the Fruitland Formation and Pictured Cliffs Sandstone (Decker et al. 1988). This distinct type of gas is generally confined to coal beds which have not migrated to adjacent



SOURCE: USGS OIL AND GAS MAP OM 138

SURFICIAL GEOLOGIC MAP INCLUDING OUTCROPS FOR THE NORTHERN PORTION OF STUDY AREA

Figure 3-5

bedrock units (Rice et al. 1988; BLM 1989). Given these differences in gas quality between the adjacent units, there appears to be no significant hydraulic connection between the bedrock units.

Hydrocarbon contamination has been detected in some shallow ground water wells in the Bondad-Cedar Hill area, which is 35 miles from the Study Area. Public concern, reported to the BLM, is that coalbed methane development in the area is the source of hydrocarbon contamination; however, this has not been clearly identified as the source. The ground water hydrocarbon contamination could be due to one or many of these factors: (1) methane gas leaking through Kirtland shale; (2) shallow formations may contain indigenous hydrocarbons; (3) old oil and gas production wells which were not adequately sealed (cemented) or abandoned; (4) shallow water disposal wells which are leaking into shallow aquifers; or (5) new oil and gas production wells which are not properly installed using present-day standardized practices and which are leaking into shallow aquifers. It appears the most probable sources of hydrocarbon contamination in the Bondad area are the shallow aquifer formations which contain natural hydrocarbon sources and which diffuse into the ground water and older production wells which may be improperly completed or abandoned (BLM 1989).

In general, improperly abandoned wells, cathodic protection holes, and other development-related holes such as geophysical shot holes, could be a potential source of ground water contamination. However, this is not expected to be a problem in the Project Study Area, since no cathodic protection holes are expected and the four wells which have been abandoned were required to be properly sealed (cemented) based upon BLM procedures. The well completion and abandonment regulations 43 CFR 3162.3 (see Appendix A-2 and A-3) require proper sealing by plugging with an inert material such as cement grout to isolate water zones to prevent any cross-contamination or migration.

<u>Ground Water Resources</u>

In general, in the San Juan Basin, ground water of sufficient quantity for beneficial domestic use occurs in the Dakota Sandstone and overlying geologic units. However, in the Study Area, the Dakota Sandstone is too deep for use as an economic ground water source. The lower Menefee Formation and Animas Formation are the most transmissive bedrock aquifers in the Study Area. Coal seams in the Menefee and Fruitland Formations are more permeable than shale or sandstones due to cleating (fractures) which developed during coal digenesis (formation) (Brooks 1985). The Lewis and Mancos Shales are generally not considered aquifers and are rarely developed as a water supply. The Mancos Shale, however, does yield water to wells in areas near landslides or in slump blocks. Major sources of ground water occur in the Terrace and alluvial floodplain deposits, which are stratigraphically higher than the Fruitland Formation. In areas of coalbed methane production, the Fruitland

Formation does not produce water in sufficient quantities and is too deep, and of poor quality, to be a viable or economic ground water supply (BLM 1989).

Recharge to the bedrock aquifers (e.g., Menefee Formation) occurs primarily in the northern margin of the San Juan Basin area where the bedrock units crop out (Brooks 1985; Ayers et al. 1988). In addition to being bounded by the impermeable Lewis and Kirtland shales, the Fruitland is isolated from other formations and can be considered a confined aquifer (Ayers et al. 1988; Fassett and Hinds 1971; Ayers et al. 1989). The degree of influence of vertical surface infiltration on the Fruitland Formation appears limited (in terms of time required to reach the Fruitland), based on observed differences in shallow aquifer and Fruitland Formation ground water quality (see ground water quality sub-section) and estimated ground water velocities in the Fruitland Formation of 1 foot in 30 years (BLM 1989). No recharge from overlying formations to the Fruitland Formation occurs due to vertical infiltration in the San Juan Basin away from the margin because of the impermeability and thickness of the units overlying the Fruitland Formation. The terrace and alluvial aquifers are recharged from surface infiltration of precipitation (Brooks 1985). These shallow aquifers also receive recharge from stream and river flow during periods of high flow.

Springs are present in the Study Area and occur in the higher elevation areas at hillside exposures where coarse, permeable saturated materials overlie low permeability clay and shales. Ground water discharge from springs varies daily and seasonally. Discharges from seeps have been observed up to 50 gpm (Brooks 1985). Higher elevation springs usually dry up during the summer and fall, while lower elevation springs are capable of sustained discharges throughout the year (Brooks 1985; Butler 1986). This suggests possible fluctuations in shallow ground water levels at higher elevations. Since the shallow formations are not directly connected with the Fruitland Formation, observed fluctuations in springs are likely attributable to variations in precipitation, stream flow, and shallow ground water withdrawal. Based on existing hydrogeological data and the known impermeability of the Lewis and Kirtland shales, the existing coalbed methane gas wells, flowlines, and disposal wells within the Study Area have not affected surface springs or seeps.

A listing of well records in the Study Area was obtained from the Colorado State Engineer's office (State of Colorado Engineer's Office 1987), which included 115 water wells within or surrounding the Study Area. In addition to well locations, information on well depth, well yield, depth to ground water, date completed, and water use was available for a majority of the wells. Review of these water well records revealed that the majority of water wells are located in two geographic areas within the project area: (1) near the western edge of the Study Area, southeast of Bayfield and along Highway 160 at the northern edge of the Study Area; and

(2) in the southeast portion of the Study Area, primarily along Stollsteimer Creek. Few wells exist in the interior of the Study Area.

Based upon the State Engineers Office records, wells in the Study Area were completed between 1908 and 1984, with the greatest number installed during the late 1960's and 1970's. According to well records, the majority of wells were installed for use as domestic wells. The next most common reported use was household only. A small number of wells were designated as domestic and/or stock wells. Two wells were listed under commercial use, and one well was listed for other (not designated) usage. This information is similar to that reported by Brodgen et al. (1979) and Brooks (1985), who found the majority of ground water wells for drinking water purposes in the Study Area are shallow wells (less than 500 feet deep), completed in the Animas Formation and in the stratigraphically higher Terrace and alluvial floodplain deposits. Well depths in the Study Area ranged from 15 feet to 330 feet, with the majority of wells completed above 150 feet in total depth. Depth to ground water was reported to be between 0 and 200 feet. Well yields recorded ranged from 0.5 to 50 gallons per minute (gpm), with the majority of the wells yielding below 20 gpm.

Water levels in some of the shallow alluvial aquifers in the San Juan Basin, including some near the bedrock outcrop area, have fluctuated or declined over the past several years. This appears to be due to lack of recent sufficient precipitation for recharge (Lyle, personal communication, 1990), pumping from limited/localized aquifers of relatively small size or increased domestic withdrawal (overutilization). Presently, insufficient data exists to define the exact causes of the lowering of shallow ground water levels. However, since the Fruitland Formation appears not to be hydraulically connected to the shallow aquifer, these water level fluctuations do not appear related to existing coalbed methane well production, including coalbed methane wells, flowlines, or disposal facilities.

Ground water pumping rates in the Alluvial aquifers typically average from 5 to 20 gpm, with a maximum rate of 25 gpm (Brooks 1985). Withdrawal rates in the Terrace Deposit aquifer are typically from 5 to 10 gpm, with a maximum pumping rate of 50 gpm (Brooks 1985). The sandstone/shale aquifers (Animas, San Jose, Kirtland, Fruitland, Pictured Cliffs, Lewis Shale, Mesa Verde Group, and Point Lookout) typically yield ground water at average pumping rates of 1 to 10 gpm, with a maximum rate of 75 gpm being reported (Brooks 1985). The shale formations are adequate aquifers when sufficient fractures are present.

Based on aquifer test results using two wells screened in three coal seams of the Fruitland Formation near the Chimney Rock mining area, estimated transmissivity values were 25 to 28 feet^2/day and storage coefficients

were 1.0 x 10^{-4} and 1.3 x 10^{-4} (Brooks 1985). Permeability of the Fruitland is higher near or at the outcrop due to the effects of weathering and lower overburden pressures (BLM 1989). Results of slug tests conducted in a well, screened in the sandstone and shale underlying the lowest coal seam of the Fruitland Formation, resulted in an estimated transmissivity of 0.3 $feet^2$/day; slug test results of a Fruitland well screened in the lowest coal seam and valley colluvium (i.e., in area of intersection of stream channel and Fruitland Formation) estimated a transmissivity value of 125 $feet^2$/day (Brooks 1985). Transmissivity values increase when the sandstone and valley colluvium is screened along with the lower coal seam of the Fruitland because of the higher permeabilities of the sandstone and valley colluvium. A transmissivity of 100 $feet^2$/day was reported for the Animas Formation in New Mexico portion of the San Juan Basin; transmissivities of 40 and 120 $feet^2$/day were reported in the New Mexico portion of the San Jose Formation (Stone et al. 1983). A transmissivity value of 13,000 $feet^2$/day and hydraulic conductivity value of 285 feet/day was reported in a well east of Chimney Rock, screened in 46 feet of Quaternary Alluvium (Brooks 1985). The hydraulic gradient of the alluvial aquifer is assumed to be equal to the stream gradient of 0.007 toward the south. (Brooks 1985; Brimhall 1973).

The above transmissivity values suggest that water moves slowly through the Fruitland Formation, while the alluvial material allows water to move more freely due to its unconsolidated nature. The Animas Formations allows water to move at a slightly higher rate when compared to the Fruitland but at a slower rate when compared to the alluvial aquifer.

Ground Water Quality

Most existing ground water quality data for the Study Area is from shallow hydrogeologic units from an area south of the Study Area. Specific ground water quality data collected within the Study Area were from the Animas and Fruitland Formations. The existing ground water quality data were supplemented by collecting and analyzing ground water samples from 11 shallow wells along the northern edge of the Study Area.

Ground water quality within the Study Area is dependent upon the rock type and depth. The sandstone, terrace, and floodplain deposits are calcium bicarbonate-rich aquifers. Aquifers largely composed of shale, and carbonaceous shale and coal (e.g., Fruitland Formation), have sodium bicarbonate-rich waters. The water quality of the floodplain aquifers is largely controlled by the water quality of the streams recharging them (Brodgen 1979; Brooks 1985; and Butler 1986). The bedrock aquifers are more mineralized than the terrace and alluvial floodplain aquifers, and exhibit spatial differences due to the interbedded and lenticular nature of

the deposit. For example, the Fruitland and Kirtland aquifers have concentrations of total dissolved solids (TDS) ranging from 222 to 7,130 mg/l, while the alluvial terrace and floodplain aquifers have TDS values ranging from 205 to 870 mg/l, and 148 to 985 mg/l, respectively (Brodgen, et al. 1979). The increased mineralization (high TDS values) of the bedrock aquifers is due to membrane effects which occur when water and solutes are driven under the influence of hydraulic head gradients across semipermeable barriers. Increased mineralization is also due to the length of time (e.g., long residence time) the water is in contact with the rock units. As ground water travels through the sedimentary rocks, movement of ionic solutes is restricted relative to ground water movement and results in an increase in salt concentrations. Ground water travel times in the deeply buried bedrock units have been estimated at 30 years to travel one foot for the Fruitland Formation (BLM 1989). These effects are especially observed in shale and clay units associated with deep deposits.

Ground water quality data for the bedrock aquifers consisted of samples collected from wells completed in the Animas Formation around the Study Area (Butler 1986), and from wells completed in the Fruitland Formation located within the Study Area (Amoco 1989). Ground water samples from the Animas Formation generally indicate acceptable water quality with little mineralization (Table 3-9) (refer to Figure 3-3 for well locations). For example, samples from the Fruitland Formation reflect increased mineralization of the deeper formation water (Table 3-10). Comparing the Fruitland Formation and the Animas Formation, ground water in the Fruitland Formation had TDS, alkalinity, and bicarbonate values which were an order of magnitude greater than water from the Animas Formation. Hardness and dissolved iron values in the Fruitland were lower than those in the Animas Formation. This increase in bicarbonate indicates that ground water in the Fruitland Formation is connate and the water derived sulfate reductions which occurred during early coal diagenesis; however, water in the Animas Formation is derived from post depositional cross-formation flow (Decker et al. 1989). Values for pH and temperature were slightly different between the two formations, with the Fruitland having a slightly increased temperature range and pH.

Ground water quality data for the shallow alluvial aquifers were obtained as part of this study, specifically along the northern boundary of the Study Area and the outcrop of the bedrock units (including the Fruitland Formation). Water quality and hydrogeologic data are presented in Table 3-11. Refer to Figure 3-3 for well locations. These data reveal low concentrations of total dissolved solids and alkalinity, implying that very little mineralization has occurred.

TABLE 3-9

GROUND WATER QUALITY DATA FROM WELLS IN ANIMAS FORMATION[1]

	Well Number						
Parameter	GW-9	GW-10	GW-11	GW-14	GW-24	GW-25	GW-27
pH	7.4	6.6	--[2]	--	8.4	7.7	7.8
Conductivity (μmhos/cm)	836	790	--	680	932	446	735
Temperature (°C)	12.0	13.5	--	9.0	12.0	13.0	11.5
Hardness (mg/ℓ as $CaCO_3$)	180	360	210	290	24	160	130
Alkalinity (mg/ℓ as $CaCO_3$)	350	312	192	323	340	200	349
Sodium (mg/ℓ)	95	37	25	46	210	35	130
Potassium (mg/ℓ)	7.4	2.2	2.1	1.4	0.5	1.5	1.6
Calcium (mg/ℓ)	58	120	68	93	8.1	48	40
Magnesium (mg/l)	7.8	14	9.1	15	0.8	8.9	7.3
Chloride (mg/l)	5.8	2.4	1.3	4.8	60	4.0	8.9
Carbonate (mg/l)	--	--	--	--	1	0	15
Bicarbonate (mg/l)	--	--	--	390	410	240	390
Sulfate (mg/l)	39	130	78	38	45	26	66
Flouride (mg/l)	0.5	0.3	0.3	0.3	5.5	0.4	0.39
Silica (mg/l)	9.8	14	10	15	8.9	11	--
Dissolved Solids (mg/l)	430	510	310	410	540	250	434

[1] Samples collected in 1974 and 1975; refer to Figure 3-3 for well locations.

[2] -- Means no data

Source: Butler 1986.
BLM 1990.

TABLE 3-10

GROUND WATER QUALITY DATA FOR WELLS IN FRUITLAND FORMATION[1]

Well[2]	Sample Date	Total Dissolved Solids (mg/ℓ)	pH	Na (mg/l)	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Cl (mg/l)	SO_4 (mg/l)	CO_3 (mg/l)	HCO_3 (mg/l)	Resistivity/ Temperature (μmhos/cm)
Payne A-1	12-3-87	2800	7.98	775	6	2	-	97	0	0	1920	3.90/72
Payne A-1	6-10-87	2674	7.73	1010	30.5	8.2	-	204	0	0	2470	1.73/66
Payne A-1	3-21-88	7350	7.27	1990	30	10	11	168	0	0	5140	1.85/66
Payne A-1	4-27-88	7278	8.02	1965	28	12.1	8	178	0	0	5087	1.7/64
Payne B-1	6-10-87	6100	7.78	1650	30.1	11.6	-	144	0	0	4270	2.32/65
Payne B-1	9-22-87	6560	7.71	17.40	30.5	5.3	59	121	0	0	4610	1.90/72.5
Payne B-1	12-3-87	6300	7.96	1700	32	7	-	119	0	0	4440	1.90/72
Payne B-1	3-21-88	3660	7.46	1390	22	6	9.2	86	0	0	3660	2.75/61
Payne C-1	6-5-87	1370	7.99	362	26	5.6	-	127	0	0	850	4.2/64
Payne C-1	6-10-87	2330	7.74	604	29.7	2.4	-	11.0	0	0	1680	5.5/65
Payne C-1	12-3-87	2380	8.07	612	29	2.0	-	15	0	0	1700	4.90/72
Payne C-1	3-21-88	2400	7.80	625	22	6	3.3	17	0	0	1730	5.30/65
Payne C-2	1-13-88	452	7.20	103	13	8	7	20	25	0	276	-
Payne C-2	1-26-88	5020	7.66	1333	32	5	96	297	10	0	3247	2.2/72
Payne C-2	1-27-88	5065	7.81	1358	24	6	90	316	12	0	3259	2.3/62
Payne C-2	2-2-88	4367	7.80	1159	27	6	89	276	5	0	2805	2.5/69

TABLE 3-10
(CONTINUED)

Well[2]	Sample Date	Total Dissolved Solids (mg/ℓ)	pH	Na	Ca	Mg	K	Cl	SO_4	CO_3	HCO_3	Resistivity/ Temperature (μmhos/cm)
				mg/l								
Payne C-2	3-21-88	3760	7.68	984	32	9	8.8	55	0	0	2670	3.5/61
Payne D-1	2-4-88	5986	7.52	1621	11	9	10	53	1	0	4281	2.2/62
Payne D-1	3-22-88	5740	7.58	1560	22	9	7.8	164	0	0	3980	2.4/63
Pine River 2-29	2-27-89	8280	7.74	2418	24	19	10	1136	0	0	4677	1.42/70
Pine River 1-30	7-27-88	10,600	7.15	3435	40	29	23	3376	0	0	3660	0.8/80
Pine River 1-30	7-27-89	10,800	7.06	3424	24	29	18	2840	0	0	4492	0.89/70

[1] Refer to Figure 3-3 for well locations.

[2] Locations of wells are presented on Figure 3-3

Source: Amoco 1990

TABLE 3-11

GROUND WATER QUALITY DATA FROM WELLS IN SHALLOW ALLUVIAL FORMATION[1]

Parameter	Well										
	26	122	119	133	142	150	88	147	39	7	1
Field pH	7.58	8.55	6.98	8.66	8.71	8.46	7.91	9.14		6.68	8.65
Lab pH	7.46	8.35	7.03	8.49	8.47	8.33	8.08	8.67	7.22	7.03	8.28
Field Conductivity (4 μmhos/cm)	340	460	380	550	760	550	270	345	750	240	1400
Lab Conductivity (μmhos/cm)	420	560	480	682	810	690	375	435	920	330	1580
Field Temperature (°C)	13.5	14.5	13.5	14.0	20.5	12.0	11.5	14.0	14.0	11.5	15.5
Total Dissolved Solids (mg/l)	282	345	305	430	535	460	240	435	645	215	1080
Hardness (mg/l as $CaCO_3$)	144	21	219	15	15	10	21	10	397	139	10
Alkalinity (mg/l as $CaCO_3$)	204	255	238	356	370	264	160	210	450	171	610
Sodium (mg/l)	40.1	125	19.8	186	195	165	80.2	97.7	68.4	16.9	415
Potassium (mg/l)	0.6	0.7	1.6	0.9	0.7	1	<.5	<.5	2.8	1.4	0.7
Calcium (mg/l)	46.1	6.3	64.2	3.5	3.6	3	5.9.7	2.7	122	44	1.1
Magnesium (mg/l)	6.5	0.8	13.7	0.5	0.5	<.5	<.5	<.5	21.6	7	<.5
Iron (mg/l)	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5
Chloride (mg/l)	<10	<10	<10	<10	38	<10	<10	<10	10	<10	58
Carbonate (mg/l)	0	14	0	29	31	14	2	34	0	0	24
Bicarbonate (mg/l)	249	284	290	376	388	293	190	188	549	210	708
Hydroxide (mg/l)	0	0	0	0	0	0	0	0	0	0	0
Sulfate (mg/l)	26	25	23	23	43	29	30	29	121	11	109
Sample Collection Location	Well Head	Well Head	Well Head	Interior Tap	Interior Tap	Exterior Tap	Well Head	Exterior Tap	Hose At Well Head	Well Head	Exterior Tap
Well Depth (ft)	155		4	210		280	140	110	40	53	125
Well Yield (gpm)	15		15			2	6	5	14.2	24	6
Water Level (ft)	60		--	22		62	0	38	20	38	60

[1] Chemical data collected as part of this study (Oct., 1989); well depth, yield and water level data collected from Colorado State Engineer's records. Refer to Figure 3-3 for well locations.

Based on the observed ground water quality data, there are differences in ground water quality between the shallow alluvial aquifers and Animas Formations, and the Fruitland Formation. These differences are significant in the basin and are even evident along the northern portion of the Study Area near the location of the bedrock outcrops. This implies that there is no significant hydraulic connection between these formations. Furthermore, this suggests that existing coalbed methane wells, disposal wells, and flowlines, using current technology have not affected the quality of ground water in formations used for potable water.

3.3 METEOROLOGY AND AIR QUALITY

The rugged topography of the Study Area causes large variations in climate within short distances, and a few climatic generalizations apply to the whole area. Generally, temperatures decrease and precipitation increases with increasing elevation. Average annual temperatures at the top of the San Juan Mountains are low, averaging less than 32°F. Temperatures as low as -50°F are occasionally observed in the winter. In the summer, temperatures average approximately 60°F, and may reach maximums of 90°F to 100°F. Table 3-12 presents temperature normals for Durango, Colorado and can be considered representative of the Study Area. Precipitation amounts are generally consistent throughout the year. August is the wettest month and June and November are the driest months. Average monthly precipitation collected at Durango, Colorado is presented in Table 3-13. Surface wind directions in the Study Area may vary greatly from location to location due to the rugged topography. Wind data for Durango, Colorado are summarized in the wind frequency distribution presented in Table 3-14. Wind directions at this station are predominantly from the west-northwest with wind speeds generally ranging from three to ten knots (3.5 to 11.5 miles per hour). Upper air wind patterns for the project area are predominantly from the west and west-southwest.

The proposed HD Mountains project is located in the Four Corners region of southwestern Colorado. The Weminuche Wilderness is located approximately 10 miles north of the northern-most extent of the Study Area. The air quality of the Study Area, including the Weminuche Wilderness, is generally good, meeting Colorado and federal standards, as it is in Federal attainment for all criteria pollutants. (The Weminuche Wilderness is defined in 40 CFR Part 52.21 as a Federal Class I Area. As such, incremental increases in ambient air quality levels of particulate matter, sulphur dioxide, and nitrogen dioxide are restricted to smaller increases than in other areas, including the project area which is defined as a Class II Area). In areas designated as Class I, Class II, or Class III, increases in pollutant concentrations over the baseline (background) concentrations are limited to the values presented in Table 3-15. Class I areas were designated by the U.S. Congress on August 7, 1977, and include International Parks, National Wilderness Areas greater

TABLE 3-12

AVERAGE MINIMUM, MAXIMUM AND AVERAGE TEMPERATURES
FOR DURANGO, COLORADO
(Period 1931-1960)

Month	Temperatures (°F)		
	Minimum	Maximum	Average
January	10	40	25
February	15	40	30
March	20	50	30
April	30	60	45
May	35	70	50
June	45	80	60
July	50	90	70
August	50	80	70
September	40	80	60
October	35	65	50
November	15	50	35
December	15	40	30
Average	30	62	46

Source: NOAA 1979.

TABLE 3-13

AVERAGE PRECIPITATION
FOR DURANGO, COLORADO
(Period 1931-1960)

Month	Precipitation (in.)
January	1.5
February	1.5
March	1.5
April	1.5
May	1.5
June	0.75
July	1.5
August	3.0
September	1.5
October	1.5
November	0.75
December	1.0
Average Annual Total	17.5

Source: NOAA 1979.

TABLE 3-14

WIND FREQUENCY DISTRIBUTION BY PERCENT FOR DURANGO, COLORADO FEBRUARY 1982 THROUGH JANUARY 1983

Wind Direction	Wind Speed Classes (knots) 0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	>21.0	Total
N	0.4	1.7	0.4	0.1	0.0	0.0	2.6
NNE	0.1	0.6	0.4	0.0	0.0	0.0	1.1
NE	0.0	0.2	0.2	0.0	0.0	0.0	0.4
ENE	0.0	0.1	0.0	0.0	0.0	0.0	0.1
E	0.0	0.1	0.0	0.0	0.0	0.0	0.1
ESE	0.1	0.2	0.2	0.0	0.0	0.0	0.5
SE	0.2	1.4	2.0	0.2	0.0	0.0	3.8
SSE	0.4	4.4	5.3	0.6	0.0	0.0	10.7
S	0.6	3.0	1.8	0.1	0.0	0.0	5.5
SSW	0.6	1.2	0.6	0.0	0.0	0.0	2.4
SW	0.7	1.5	0.6	0.0	0.0	0.0	2.8
WSW	1.5	1.4	1.2	0.4	0.0	0.0	4.5
W	2.0	3.8	3.4	1.5	0.0	0.0	10.7
WNW	2.9	18.4	18.4	1.0	0.1	0.0	40.8
NW	1.5	5.2	2.1	0.5	0.0	0.0	9.3
NNW	0.9	3.1	0.6	0.2	0.0	0.0	4.8
All	12.0	45.9	37.3	4.8	0.1	0.0	100.1

Notes: Occurrence of calms is 0.3 percent.
Total number of invalid observations = 675.
Total number of valid observations = 8098.
Data recovery rate = 92.3 percent.

Source: Dames and Moore 1982.

TABLE 3-15

MAXIMUM ALLOWABLE POLLUTANT INCREASE
OVER THE BASELINE CONCENTRATION IN
CLASS I, CLASS II, AND CLASS III AREAS

Pollutant	$\mu g/m^3$
CLASS I	
Particulate matter:	
TSP, annual geometric mean	5
TSP, 24-hr. maximum	10
Sulfur dioxide:	
Annual arithmetic mean	2
24-hr. maximum	5
3-hr. maximum	25
CLASS II	
Particulate matter:	
TSP, annual geometric mean	19
TSP, 24-hr. maximum	37
Sulfur dioxide:	
Annual arithmetic mean	20
24-hr. maximum	91
3-hr. maximum	512
CLASS III	
Particulate matter:	
TSP, annual geometric mean	37
TSP, 24-hr. maximum	75
Sulfur dioxide:	
Annual arithmetic mean	40
24-hr. maximum	182
3-hr. maximum	700

Source: 40 CFR Part 52.21

than 5,000 acres in size, National Memorial Parks greater than 5,000 acres in size, and National Parks greater than 6,000 acres in size. All other areas of the country are defined as Class II or Class III areas, with Class III being reserved for extreme high-pollution areas. A summary of the regional ambient air quality is provided in Table 3-16. Colorado and federal standards for ambient air quality are presented in Table 3-17. The air-borne contaminant source data presented in Table 3-18 were obtained from the permit files of the Colorado Department of Health (CDOH 1990). None of these contaminant sources are located on NFS land and no new sources located on NFS land were identified. Emission rates for power plants located in northwestern New Mexico which may contribute to the background pollutant levels of the Study Area are presented in Table 3-19. The values presented in Table 3-16 are considered by the Colorado Air Quality Commission to be representative of existing (background) conditions. They are, therefore, considered appropriate for assessing cumulative air quality impacts when combined with the projected air quality impacts from proposed new facilities in the Study Area.The closest visibility measurements to the Study Area are collected at Mesa Verde National Park and at the Weminuche Wilderness. The median standard visual range at Mesa Verde National Park ranged from approximately 120 to 220 kilometers for the years 1986 through 1989. The median standard visual range for the Weminuche Wilderness for the same period ranged from approximately 150 to 300 kilometers (Air Resource Specialists 1990). The visibility measurements collected at these locations can be considered representative of the Study Area.

Uranium has been reported in the Fruitland Formation at one location approximately 50 miles southwest of the Study Area (Fassett and Hinds 1971). Radon is often associated with radioactive deposits and may be present locally in the Fruitland Formation. In southwest Colorado, radioactive ores are generally associated with Jurassic Age deposits which are much deeper than the coalbed methane producing zones of the Cretaceous Fruitland Formation. Therefore, the probability of releasing radon gas is low. Furthermore, should radon gas be detected at one location, this does not indicate that it will be detected in adjacent areas (Lammering 1990). Any radon gas tapped by a CBM well would be contained within the closed CBM gas production system. However, should radon gas be released into the atmosphere at a well site, it would likely be a very small quantity and be quickly dispersed, posing minimal health or environmental risk since exposure to higher levels of radon gas in areas of Colorado is related to confined or closed spaces (i.e., basements).

TABLE 3-16

AMBIENT AIR QUALITY MEASUREMENTS AT SELECTED LOCATIONS NEAR THE HD MOUNTAINS COALBED METHANE FIELD DEVELOPMENT EIS STUDY AREA

	Total Suspended Particulate $\mu g/m^3$ [1]		Sulfur Dioxide ppm[4]			Nitrogen Dioxide ppm	Ozone ppm	Carbon Monoxide ppm		Lead ppm
	Anl Geo Mean[2]	2nd Max[3] 24-hr	Anl Mean	2nd Max 3-hr	2nd Max 24-hr	Anl Mean	2nd Max 1-hour	2nd Max 1-hour	2nd Max 8-hour	3-month Average
Rural	15	50	.005	.01	.01	.002	.05	2.0	2.0	0.05
Cortez	40	100	.005	.01	.01	.002	.05	2.0	2.0	0.3
Durango	65	195	.005	.01	.01	.002	.05	2.0	2.0	0.7
Pagosa Springs	110	345	.005	.01	.01	.002	.05	2.0	2.0	0.3
Mesa Verde	10	50	.005	.01	.01	.002	.05	2.0	2.0	.01

1 $\mu g/m^3$ = micrograms per cubic meter
2 Anl Geo = Annual geometric mean
3 2nd Max = 2nd highest value recorded for the year. This is the value to be compared to the standard.
4 ppm = parts per million

Source: Colorado Air Quality Control Commission 1987.

TABLE 3-17

COLORADO AND FEDERAL AIR QUALITY STANDARDS

Pollutant	Averaging Times	Standard
Carbon Monoxide	1-hour 8-hours	40,000 $\mu g/m^3$ 10,000 $\mu g/m^3$
Nitrogen Dioxide	Annual	100 $\mu g/m^3$
Ozone	1-hour	235 $\mu g/m^3$
Sulfur Dioxide	3-hours 24-hours Annual	1300 $\mu g/m^3$ 365 $\mu g/m^3$ 80 $\mu g/m^3$
Total Suspended Particle	24-hr primary Annual	260 $\mu g/m^3$ 75 $\mu g/m^3$
PM-10	24-hr primary Annual	150 $\mu g/m^3$ 50 $\mu g/m^3$
Lead	Calendar Quarter	1.5 $\mu g/m^3$

Source: Colorado Air Quality Control Commission 1987.

TABLE 3-18
REGIONAL EMISSION SOURCES REPRESENTATIVE
OF THE STUDY AREA

SOURCE	UTM (*) COORDINATES	STACK PARAMETERS HEIGHT (ft.) (*)	DIAMETER (ft.) (*)	TEMPERATURE (deg. F) (*)	FLOW RATE (cfm)(*)	EMISSION RATES (tons per year) VOC (*)	CO (*)	NOX (*)	SO2 (*)	TSP (*)	UTILIZATION HR/D	D/WK	WK/YR
AMOCO PRODUCTION COMPANY LOS PINOS STATION	275.0 4129.0	8	0.3	600	1300	1	2	0	0	0	24	7	52
COLO DEPT OF HYWS No. 5010	244.4 4128.6	25	5	150	9000	0	0	0	0	1	8	5	18
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	83	3.5	900	8306	0	1	5	0	0	24	7	51
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	45	3.5	900	30392	3	20	48	0	6	24	7	51
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	25	2	750	5789	2	10	77	0	0	24	7	26
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	25	2	750	5789	2	10	77	0	0	24	7	26
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	25	2	750	5789	4	0	155	0	0	24	7	51
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	25	2	750	5789	4	20	155	0	0	24	7	51
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	25	2	750	5789	4	20	155	0	0	24	7	51
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	25	2	750	5789	4	20	155	0	0	24	7	51
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	28	2.6	900	14910	0	7	18	0	1	24	7	51
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	28	1	750	14910	1	6	46	0	0	24	7	51
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	28	1	750	14910	1	6	46	0	0	24	7	51
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	28	3	900	9321	0	2	9	0	0	24	7	51
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	45	8.3	281	12924	7	26	228	0	5	24	7	52
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	45	8.3	281	12924	7	26	228	0	5	24	7	52
NORTHWEST PIPELINE CORP IGNACIO PLANT	252.8 4114.8	20	1.3	300	3750	0	2	8	0	0	24	7	52
STROHECKER EXCAVATING	260.2 4123.8	0	0	300	0	0	0	0	0	1	7	5	52
STROHECKER EXCAVATING	269.3 4123.0	6	2	180	15000	0	0	0	1	1	8	5	24
EL PASO NATURAL GAS BONDAD STATION	244.5 4106.5	35	3.3	610	6720	0	7	17	0	1	24	7	52
EL PASO NATURAL GAS BONDAD STATION	244.5 4106.5	35	3.3	610	6720	0	7	17	0	1	24	7	52
PUEBLO COAL CARBON JUNE MINE	246.5 4125.5	0	0	77	0	0	0	0	0	187	10	7	51
PEERLESS RESOURCES	251.8 4130.0	0	0	0	0	0	0	0	0	34	8	5	50
PEOPLES NATURAL GAS	238.2 4124.2	12	0.7	925	2000	1	4	29	0	0	24	7	52
LADD PETROLEUM	252.7 4103.9	14	0.7	1075	2300	3	15	119	0	0	24	7	52
LADD PETROLEUM	257.5	14	0.8	1075	5300	4	24	32	0	0	24	7	52

TABLE 3-18
REGIONAL EMISSION SOURCES REPRESENTATIVE
OF THE STUDY AREA

SOURCE	UTM (*) COORDINATES	STACK PARAMETERS HEIGHT (ft.) (*)	DIAMETER (ft.) (*)	TEMPERATURE (deg. F) (*)	FLOW RATE (cfm)(*)	EMISSION RATES (tons per year) VOC (*)	CO (*)	NOX (*)	SO2 (*)	TSP (*)	UTILITIZATION HR/D	D/WK	WK/YR
	4105.4												
NEILS EXCAVATION	271.5 4140.0	0	0	0	0	0	0	0	0	6	10	6	26
ANIMAS AGGREGATES	250.5 4145.0	0	0	0	0	0	0	0	0	0	8	5	40
M-K FERGUSON	244.0 4128.3	0	0	0	0	0	0	0	0	810	10	6	35
M-K FERGUSON	242.3 4126.3	0	0	0	0	0	0	0	0	647	10	6	35
REPUBLIC MINERAL CORPORATION	252.5 4104.5	14	0.7	1000	3260	0	2	16	0	0	24	7	52
AMOCO PRODUCTION SALVADOR STATION	267.2 4106.6	20	1.2	700	1600	1	2	19	2	0	24	7	52
AMOCO PRODUCTION SALVADOR STATION	267.2 4106.6	3	1.2	700	2850	1	4	29	3	0	24	7	52
AMOCO PRODUCTION MAYFIELD STATION	259.4 4120.5	11	1	800	2850	1	4	32	3	0	24	7	52
AMOCO PRODUCTION TIFFANY STATION	253.0 4115.7	15	1.2	500	4705	7	27	18	9	0	24	7	52
AMOCO PRODUCTION TIFFANY STATION	253.0 4115.7	15	1.2	500	4705	7	28	18	0	0	24	7	52
AMOCO PRODUCTION TIFFANY STATION	253.0 4115.7	15	1.2	500	4705	7	28	18	0	0	24	7	52
AMOCO PRODUCTION TIFFANY STATION	253.0 4115.7	15	1.2	500	4705	7	28	18	0	0	24	7	52
AMOCO PRODUCTION TIFFANY STATION	253.0 4115.7	15	1.2	500	4705	7	28	18	0	0	24	7	52
AMOCO PRODUCTION TIFFANY STATION	278.0 4106.5	6	1.2	700	3154	1	5	38	3	0	24	7	52
AMOCO PRODUCTION TIFFANY STATION	278.0 4106.5	8	1.2	700	4880	3	11	85	7	0	24	7	52
AMOCO PRODUCTION LIMON STATION	254.3 4118.2	6	1.2	700	4000	2	7	57	5	0	24	7	52
AMOCO PRODUCTION LIMON STATION	254.3 4118.2	3	1.2	700	3154	1	5	38	3	0	24	7	52
AMOCO PRODUCTION SOUTHERN UTE STATION	271.1 4117.5	8	0.5	800	300	0	1	4	0	0	24	7	52
AMOCO PRODUCTION SOUTHERN UTE STATION	271.1 4117.5	8	0.5	800	300	0	1	4	0	0	24	7	52
AMOCO PRODUCTION WHEELER STATION	245.8 4120.8	12	1.2	700	4200	3	8	64	0	0	24	7	52
AMOCO PRODUCTION BAYFIELD STATION	267.0 4122.5	15	1.2	500	4705	7	27	18	0	0	24	7	52
AMOCO PRODUCTION COTTONWOOD GULCH	253.0 4115.7	6	1.2	700	3154	1	5	38	0	0	24	7	52
AMOCO PRODUCTION COTTOMWOOD GULCH	253.0 4115.7	6	1.2	700	3154	1	5	38	0	0	24	7	52
HAWKINS TRUCKING AND EXCAVATING	319.7 4123.5	0	0	0	0	0	0	0	0	14	6	5	32

TABLE 3-18
REGIONAL EMISSION SOURCES REPRESENTATIVE
OF THE STUDY AREA

SOURCE	UTM (*) COORDINATES	STACK PARAMETERS HEIGHT (ft.) (*)	DIAMETER (ft.) (*)	TEMPERATURE (deg. F) (*)	FLOW RATE (cfm)(*)	EMISSION RATES (tons per year) VOC (*)	CO (*)	NOX (*)	SO2 (*)	TSP (*)	UTILITIZATION HR/D	D/WK	WK/YR
HAWKINS TRUCKING AND EXCAVATING	319.7 4123.5	0	0	0	0	0	0	0	0	2	6	5	32
					TOTALS	105	461	2194	36	1722			

(*) EXPLAINATION OF ABBREVIATIONS

UTM - UNIVERSAL TRANSVERSE MERCATOR COORDINATE SYSTEM
ft - FEET
deg. F - DECREES FAHRENHEIT
CFM - CUBIC FEET PER MINUTE
VOC - VOLATILE ORCANIC COMPOUNDS
CO - CARBON MONOXIDE

NOX - OXIDES OF NITROCEN
SO2 - SULFUR DIOXIDE
TSP - TOTAL SUSPENDED PARTICULATES
HR/D - HOURS PER DAY
D/WK - DAYS PER WEEK
WK/YR - WEEKS PER YEAR

TABLE 3-19

NEW MEXICO POWER PLANT EMISSIONS

Power Plant	UTM[1] Coordinates (m)[2] E[3]	N[4]	Emission Rate (tons/yr) TSP[5]	SO_2[6]	NO_x[7]	Year
Four Corners Power Plant	732,000	4,067,000				1988
Unit 1			377	36,326	84,966	
Unit 2			377			
Unit 3			442			
Unit 4			1,537			
Unit 5			1,537			
San Juan Power Plant	737,000	4,075,800				1988
Unit 1			728	6,636	4,555	
Unit 2			728	3,547	5,682	
Unit 3			1,103	7,540	5,183	
Unit 4			1,103	10,772	7,434	

Source: New Mexico Environmental Improvement Division 1990.

[1] UTM = Universal Transverse Mercator Coordinate System
[2] m = meters
[3] E = East coordinate
[4] N = North coordinate
[5] TSP = Total Suspended Particulates
[6] SO_2 = Sulphur dioxide
[7] NO_x = Oxides of nitrogen

3.4 VEGETATION, TIMBER, AND GRAZING

3.4.1 General Vegetation

The HD Mountains Study Area contains vegetation typical of the foothills and mountain zone of the southern Rocky Mountains (Table 3-20). Natural vegetation is predominant, with agriculture confined to inholdings of private land on the edges of the Study Area (Figure 3-6). The distribution of natural vegetation is determined by elevation (6,300 to 8,900 feet), topography, precipitation, soils, land management, and other factors. About 37 percent of the Study Area is forested, principally at higher elevations and on north-facing slopes. The remainder of the Study Area includes piñon-juniper woodland, Gambel oak, sagebrush, and grassland. Riparian and wetland vegetation is limited and occurs mostly on the floodplains of major streams. Each of the major vegetation types is described below.

Ponderosa Pine

This is the most widespread vegetation type, occupying about 30 percent of the Study Area. It occurs predominantly in the lower mountain zone from about 6,800 to 7,800 feet in elevation, mainly on areas of gentle slope and on north-facing slopes and valleys. About 6,367 acres (11 percent of the Study Area) consists of commercial-grade timber on NFS land, and small portions have been cut for timber within the past ten years. Gambel oak is abundant as an understory species; other common species include serviceberry, bitterbrush, creeping mahonia, Woods rose, snowberry, Rocky Mountain juniper, muttongrass, wildrye, sedges, lupine, golden banner, and yarrow. Portions of the ponderosa pine type consist of mature and old growth timber, with trees over 150 years in age. The acreage of mature and old growth forest in the HD Mountains Study Area is not known, but is probably similar to its occurrence in the San Juan National Forest (FS 1990).

Mixed Conifer

Mixed conifer forest occupies 6.5 percent of the Study Area, mostly on north-facing slopes at higher elevations. Areas identified as mixed conifer are dominated by a mixture of tree species, including Douglas fir, ponderosa pine, white fir, and aspen, with blue spruce and subalpine fir in limited areas. Common species in these types include Gambel oak, Woods rose, snowberry, creeping mahonia, peavine, meadowrue, goldenbanner, brome, vetch, pseudocymopterus, false solomon seal, strawberry, and sedges. Most of the mixed conifer stands on NFS land are classified as commercial-grade timber, although no logging has occurred in recent years and none

TABLE 3-20

VEGETATION TYPES PRESENT IN THE
HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT
EIS STUDY AREA[1]

Vegetation Type Area	Approx. Acres	Percent of Total
FOREST TYPES		
Ponderosa Pine	16,664	29.3
Mixed Conifer	3,714	6.5
Cottonwood Woodland	411	0.7
Subtotal	20,789	36.5
NON-FOREST TYPES		
Pinyon-juniper	14,342	25.2
Gambel Oak	13,092	23.0
Sagebrush	3,947	6.9
Grassland	1,732	3.0
Rockland, Talus, Scree	139	0.2
Willow Shrub	121	0.2
Herbaceous Wetland	215	0.4
Subtotal	33,588	58.9
OTHER		
Cropland and pasture	2,533	4.5
TOTAL	56,910	99.9

[1] Source: Forest Service Resource inventory mapping supplemented by air photo interpretations and field reconnaissance.

is currently planned. Mature and old growth mixed conifer stands are common, and are estimated to occupy about half of the mixed conifer forest area, based on occurrence within the whole San Juan National Forest (FS 1990).

Riparian Woodland

Cottonwood woodland, dominated by narrowleaf cottonwood, occurs on the floodplain of the Piedra River and in narrow bands along other drainages. Other common woody species present in this type include skunkbush sumac, Rocky Mountain juniper, silverberry, Gambel oak, western virginsbower, Woods rose, hawthorn, willows, and barberry. Riparian woodland occupies about 0.7 percent of the Study Area (Figure 3-7).

Piñon-Juniper

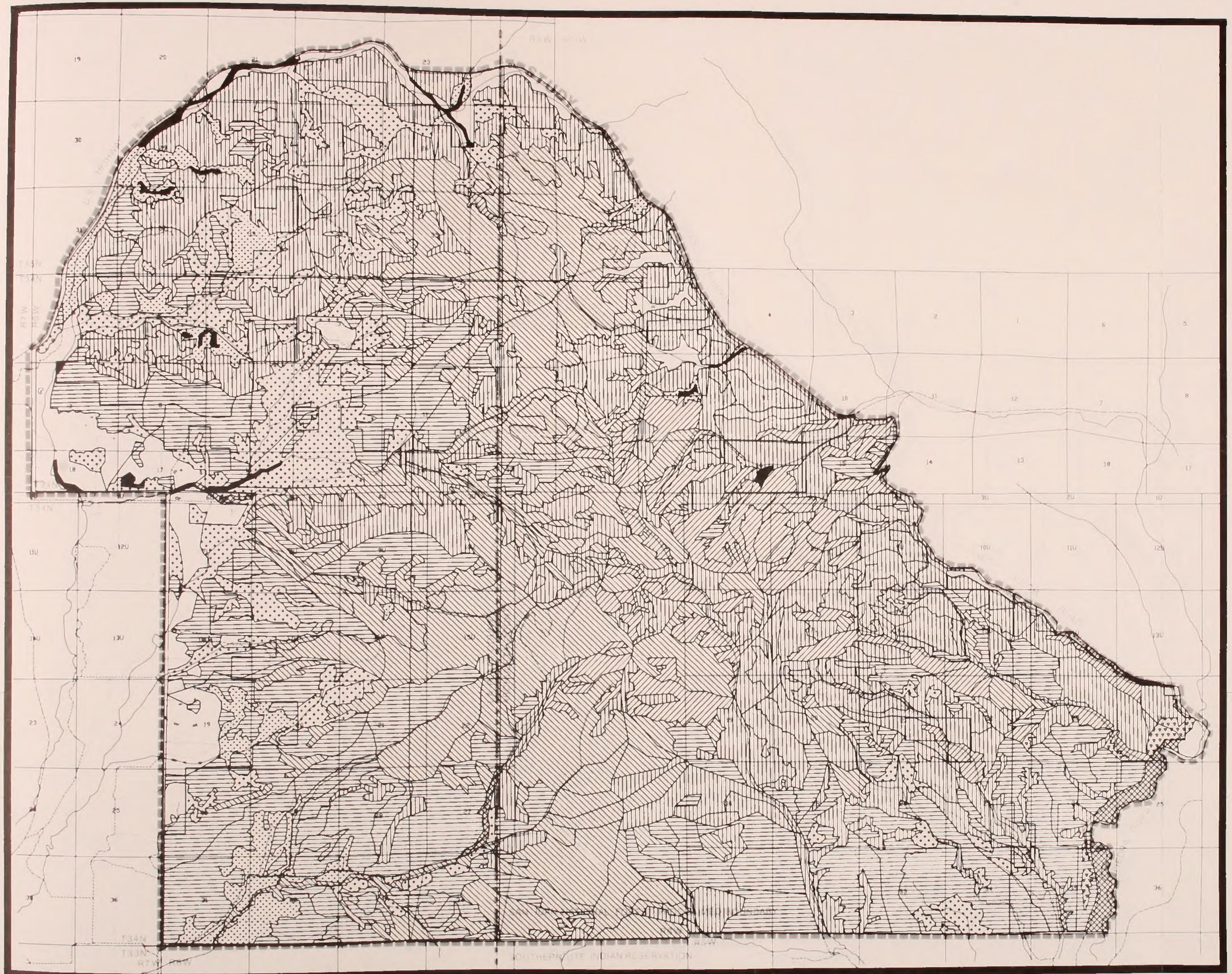
Woodland dominated by piñon pine and Utah juniper occupies about 25 percent of the Study Area. This type covers much of the southern and western portions of the Study Area, and occurs on hills and slopes up to about 8,000 feet. Common associated species include big sagebrush, mountain mahogany, Gambel oak, serviceberry, bitterbrush, Indian ricegrass, western wheatgrass, needle-and-thread, mutton grass, skyrocket gilia, fleabane, and eriogonum.

Gambel Oak

The oakbrush type occupies about 23 percent of the Study Area. It occurs primarily at elevations above 7,500 feet, on the steep upper slopes of the HD Mountains. Gambel oak typically forms a dense and sometimes impenetrable scrub 5 to 15 feet tall. Associated species include chokecherry, snowberry, Woods rose, bracken fern, and ligusticum.

Sagebrush and Grassland

These two types occur mostly on flats and valley bottoms below 7,200 feet, and together occupy about 10 percent of the Study Area. They form most of the primary livestock grazing range within the National Forest. Much of the sagebrush type is comparatively open and dominated by grasses and forbs. Common



VEGETATION

- PONDEROSA PINE
- MIXED CONIFER
- COTTONWOOD WOODLAND
- PINYON JUNIPER
- GAMBEL OAK
- SAGEBRUSH
- GRASSLAND
- ROCKLAND, TALUS, SCREE
- MARSH, WET MEADOW AND WILLOW SHRUB
- CROPLAND AND PASTURE

NORTH

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

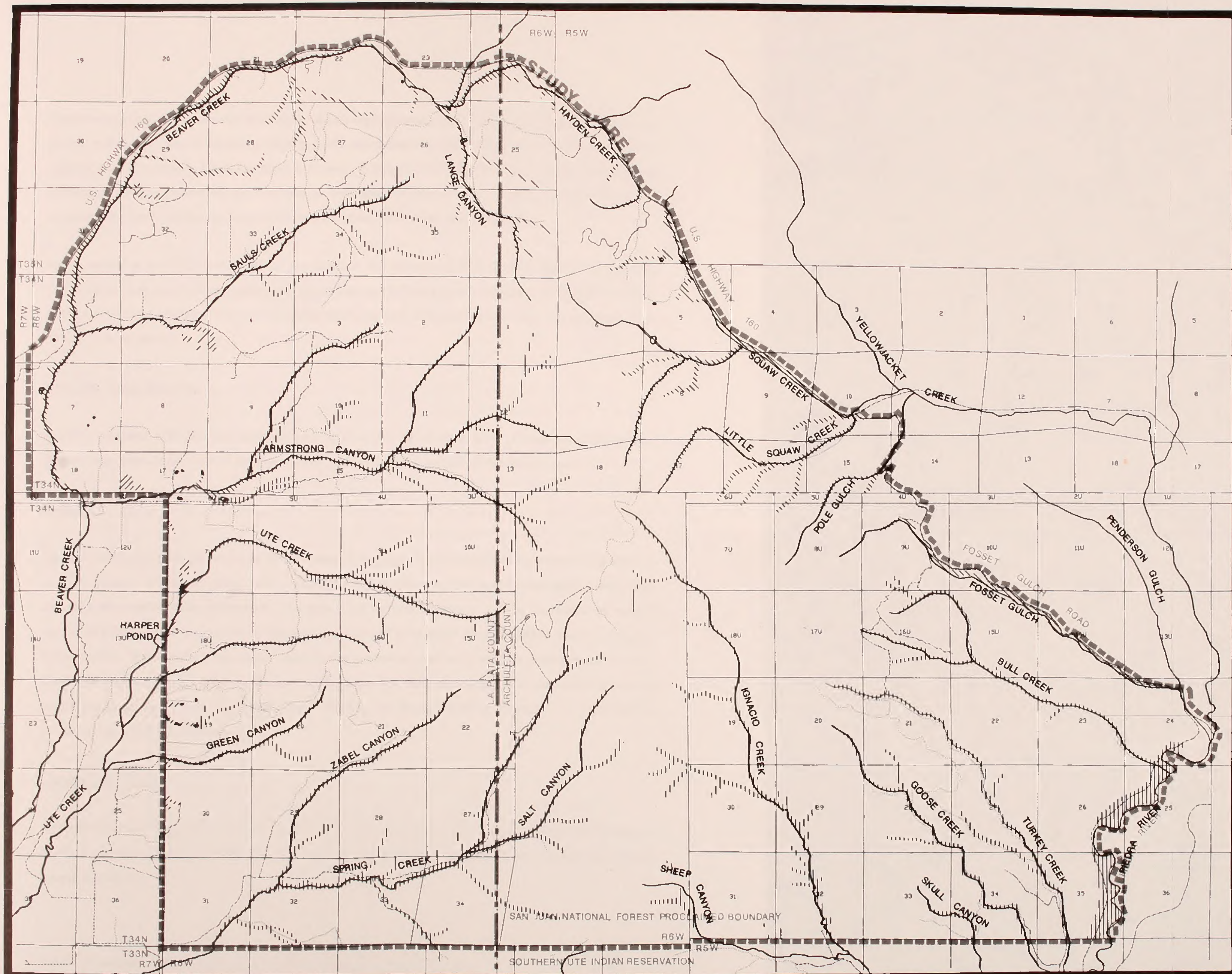
ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 3-6



WETLANDS AND RIPARIAN AREAS

/// WETLANDS

||| RIPARIAN AREAS

\\\ WETLANDS/RIPARIAN AREAS

STREAMS

NOTE: WETLAND AND RIPARIAN AREAS ARE OVER EXAGGERATED FOR CLARITY

NORTH

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 3-7

plant species in lower elevation sagebrush areas include big sagebrush, rubber rabbitbrush, western wheatgrass, broom snakeweed, prairie junegrass, mutton grass, squirreltail, yarrow, fringed sage, lupine, eriogonum, goldeneye, and pussytoes. Silver sagebrush is common in portions of the Sauls Creek drainage, and fourwing saltbush and black greasewood are common on flats near Crowbar Creek. Higher elevation stands are dominated by black sagebrush, dwarf rabbitbrush, western wheatgrass, and milkvetch.

Areas mapped as grassland include natural grassland, as well as areas on NFS land that have been cleared of sagebrush and reseeded to form a grassland. The species present are generally the same as in sagebrush areas. Crested wheatgrass, clover, and re-invading big sagebrush and rabbitbrush are common in grassland areas cleared from sagebrush.

Rockland, Talus, and Scree

Sparsely vegetated cliffs and rock outcrops occur at a number of locations, most of them too small to map. Several large areas occur west of the Piedra River and occupy 0.2 percent of the Study Area.

Wetlands

Wetland vegetation primarily occurs at isolated areas of high ground water in flat valley bottoms and adjacent to some streams. Two types occur, willow shrub and herbaceous wetlands, in wet subirrigated areas which generally have hydric soils, hydrophytic vegetation, and wetland hydrology. Areas dominated by several species of willow shrubs occur in valley bottoms on portions of some major streams, such as Beaver Creek and Fosset Gulch. Wet meadows and marsh vegetation is present in small areas of high ground water in Sauls Creek and other locations. Common species include Baltic rush, Nebraska sedge, other species of sedges and rushes, cattail, spike-rush, redtop, foxtail barley, licorice, and checkermallow. Wetlands occupy about 0.4 percent of the Study Area (Figure 3-7).

Cropland and Pasture

Agricultural areas occupy about 5 percent of the Study Area on private inholdings within the Forest boundary. Most of this type consists of irrigated hay and pasture, dominated by species such as orchardgrass, smooth brome, and alfalfa.

3.4.2 Rare or Sensitive Plant Species

Species of special concern include federally listed threatened or endangered species, federal candidate species, and species listed as rare or sensitive by the Colorado Natural Areas Program (CNAP 1989b) or other sources (O'Kane 1989; Colorado Native Plant Society (CNPS) 1989b). No federally listed or proposed species are known or expected to occur, but four sensitive species occur in the general area.

Frosty bladderpod and Pagosa gilia are both known to occur in northern Archuleta County, mostly near Pagosa Springs. Neither species has been found in the Study Area, and the nearest location is near Dyke, about 10 miles to the east. These species occur in oak scrub, grassland, and open stands of ponderosa pine, on substrates derived from Mancos Shale (CNPS 1989), at elevations of 6,500 to 7,200 feet. Both species are endemic to Archuleta County, occurring nowhere else. Both are Category 2 candidate species for the federal endangered species list, and are included in Category 1 on the Colorado state list (Table 3-21).

Two other state-listed species, Arboles milkvetch and Aztec milkvetch, are known to occur within the Study Area in lower Spring Creek Valley and at other locations near the Study Area. Arboles milkvetch was also observed in the northeastern portion of the Study Area during preparation of this EIS. Both species are endemic to the upper San Juan River Basin in La Plata and Archuleta Counties, Colorado, and adjacent portions of New Mexico. They occur principally on low hills and mesas, in juniper and sagebrush habitats, at elevations of 5,400 to 8,000 feet.

3.4.3 Sensitive or Unique Plant Communities

Areas considered under this heading include FS-designated research natural areas, and areas designated as Colorado Natural Areas or unique or exemplary plant communities under the CNAP. None of these areas occur within the Study Area (CNAP 1989).

Wetland and riparian areas are generally considered sensitive, due to their importance to wildlife and other functional values and because of federal policies. Their habitats are of limited occurrence in the Study Area and are discussed above.

TABLE 3-21

ENDANGERED, THREATENED, RARE OR SENSITIVE PLANT SPECIES[1]

Common Name	Species	Federal Status[2]	State Status[3]	Occurrence
Frosty bladderpod	Lesquerella pruinosa	2	1	Low Potential
Pagosa or many-flower gilia	pompopsis polyantha var. polyantha	2	1	Low Potential
Aztec milkvetch	Astragalus proximus	-	2	Known to Occur
Arboles milkvetch	Astragalus oocalycis	3c	4	Known to Occur

1 Source: Colorado Natural Areas Program 1989a; O'Kane 1989; Colorado Native Plant Society 1989.

2 Federal Status (U.S. Fish and Wildlife Service, 1985):
Category 2 = Species for which further information is necessary to support listing as threatened or endangered by the U.S. Fish and Wildlife Service.
Category 3C = Species which are no longer being considered for threatened or endangered status by the U.S. Fish and Wildlife Service because they are more abundant or widespread than originally thought and/or not subject to any identifiable threat.

3 Colorado State Status (Colorado Natural Areas Program 1989):
Category 1 = Federal threatened or endangered plant species and species that are rare throughout their range, including a number of species which only occur in Colorado.
Category 2 = Plants rare in Colorado but relatively common elsewhere within their range.
Category 4 = Plants of limited distribution or special interest which appear at this time (watch list).

3.4.4 Timber and Grazing

The vegetation of the Study Area provides many services including watershed protection, habitat for game and non-game wildlife, scenery and recreation, livestock forage, and timber and firewood production. Timber and grazing in the Study Area are described below.

Timber

About 37 percent of the HD Mountains Study Area is forested, and about 16 percent (8,951 acres) on NFS land is classified as land capable, available, and suitable for timber production (FS 1989). Most of the land suitable for timber production consists of sawtimber-size ponderosa pine (5,568 acres) and sawtimber-size mixed conifer (2,584 acres), with the remainder mainly poletimber ponderosa pine and mixed conifer. This represents about 1.1 percent of the commercial timber land within the San Juan National Forest. The remaining forested portions of the Study Area on NFS land are unsuitable for timber production due to poor productivity, poor stocking, heavy oakscrub occurrence, steep slopes, or other reasons. About 3,650 acres of NFS land within the Study Area are located on private land, and about 335 acres on Colorado state land; both consist primarily of ponderosa pine. No information is available about timber suitability or recent harvest history on private lands within the Study Area.

None of the commercial timber in the Study Area is designated for intensive timber production under the current San Juan National Forest Land and Resource Management Plan (Forest Plan) (WFS 1983). Timber production is allowed when it meets other FS management objectives, which primarily emphasize wildlife habitat, grazing, and recreation and scenic values.

Three FS timber sales have been held in the past ten years. These involved a 157-acre area in the Sauls Creek drainage, a 214-acre area in Fosset Gulch (partly in the Study Area), and a 552-acre area in Bull Canyon. All three involved sanitation salvage, thinning, and stand improvement of second growth ponderosa pine. A sale of 238 acres of ponderosa pine in Zabel Canyon is included in the Forest Plan (FS 1983) for 1989, but the sale did not take place.

Firewood collection and personal Christmas tree harvest occur within the Study Area, and are regulated by the FS.

Grazing

About three-quarters of the NFS land in the Study Area is included in range allotments (Table 3-22). Three allotments are present, totalling 851 animal unit months (AUM), the average amount of forage necessary to support one 1000-lb. cow for one month, about 780 pounds of air dry forage. This represents about 0.5 percent of the forage allotted to livestock in the San Juan National Forest. The primary range in the allotments is mainly grassland and sagebrush in bottomlands and valleys; the secondary range includes open ponderosa pine forest, piñon-juniper woodland, and Gambel oak scrub. The main forage species are western wheatgrass, Kentucky bluegrass, junegrass, squirreltail, needlegrass, and brome. Much of the area in the allotments is unavailable for livestock use because of steep slopes, dense brush, or poor forage production. Range condition is primarily good and trends are mostly stable to improving. All three allotments are managed under a rest rotation grazing system, using pastures separated by fences and topographic barriers. Under the Forest Plan, most of the Sauls Creek allotment and portions of the other two have a primary management emphasis on livestock grazing. The remainder of the allotment areas have a management emphasis on wildlife habitat, scenic quality, or recreation. The areas open to livestock are only grazed in the spring, prior to development of hot, dry weather.

The remainder of the Study Area (13,280 acres) is in the Turkey Creek Wildlife Area and is not currently open to livestock grazing. This area was formerly part of the Turkey Creek allotment, but was closed to grazing in 1969 due to unacceptable range conditions and erosion.

Range improvements have included sagebrush clearance and re-seeding in some areas, construction of fences and cattleguards, numerous checkdams for erosion control, development of water sources, and control of noxious weeds.

Much of the private land in the Study Area is used for cattle grazing or hay production to support livestock operations.

3.5 WILDLIFE AND FISHERIES

The HD Mountains Study Area is located in the San Juan River Basin of southwestern Colorado. This section addresses habitats, threatened and endangered species, big game, fisheries, and other wildlife groups of concern that are present, or potentially present, in and around the Study Area.

TABLE 3-22

FS GRAZING ALLOTMENTS IN THE HD MOUNTAINS STUDY AREA[1]

Name	Type	Total Area (NF Acres)	Suitable Range Acres	AUMs	Grazing Period	Management
Saul's Creek	Cattle & Horse	7,399	4,685	354	5/16-6/30 (110 head) 5/16-6/20 (88 head)	3 pasture rest rotation
H.D.	Cattle & Horse	21,951	7,066	385	6/1-7/5	5 pasture rest rotation
Turkey Creek[2]	Cattle & Horse	8,345	903	112	6/1-6/20	2 pasture rest rotation

[1] Source: Forest Service allotment management plans.
[2] Extends outside Study Area.

3.5.1 Habitats Present

Aquatic habitats present in the Study Area include the Piedra River, a moderate sized tributary of the San Juan and Colorado rivers that empties into Navajo Reservoir, portions of Beaver, Hayden, Squaw, and Yellowjacket Creeks (all perennial), and a number of intermittent creeks that are tributaries to the Piedra or Los Piños (Pine) rivers (Figure 3-7). The perennial creeks and the Piedra River run along the northern and eastern peripheries of the Study Area. Small ponds are extremely limited in the study area.

The Study Areas contains the northern two-thirds of the HD Mountains. Terrestrial habitats present range from riparian vegetation at 6,300 feet along the Piedra River to spruce-fir forests at 8,936 feet on Pargin Mountain.

Fairly extensive cottonwood stands flank the lower sections of the Piedra River and extend as narrow stringers a short distance up some of the intermittent eastern tributaries. Above the cottonwood riparian zone is a grassland/sagebrush vegetation type that occurs at lower elevations on both the eastern and western slopes of the HD Mountains. This type, in particular, is grazed by domestic cattle. It is most extensive on the western side of the Study Area where it extends up canyons and forms moderately-sized parks in the Study Area's northwest corner. In the Study Area's southeastern corner, stringers and islands of piñon pine and juniper are interspersed in the grasslands. Much of the sagebrush and piñon-juniper types immediately off NFS land have been cleared on the lower, southeastern Study Area slopes for irrigated and fertilized agricultural land primarily oriented toward hay production.

Open and closed ponderosa pine forest occurs above the grassland and piñon pine types and is probably the most extensive type in the Study Area. Ponderosa pine understories are primarily Gambel oak, with serviceberry, Wood's rose, and mountain mahogany. Interspersed are small to extensive oakbrush stands. Aspen occurs as stringers along some of the intermittent drainages and in a few stands on northern slopes, but this type is not common in the area. Douglas fir, white fir, Englemann spruce, and subalpine fir stands are present at upper elevations of the HD Mountains, particularly on north-facing slopes. These species often intergrade, depending on aspect, elevation, and substrate, to the extent that they are most commonly associated in a mixed conifer type.

Upper elevations, and most of the Study Area, occur in the San Juan National Forest. Private land occurs along the east, north, and west flanks of the Study Area. The Southern Ute Indian Reservation borders the Study Area on the south. Land use on private land is primarily agricultural. Gas well development has

occurred throughout the Study Area, but is most concentrated at lower elevations along the western third and southeastern corner of the Study Area. Some logging occurs on the Forest and the area is moderately used for recreation, especially during the hunting seasons.

3.5.2 Threatened, Endangered, and Candidate Species

The U.S. Fish and Wildlife Service (USFWS) identified the black-footed ferret (Mustela nigripes), peregrine falcon (Falco peregrinus), bald eagle (Haliaeetos leucocephalus), Colorado squawfish (Pbychocheilus lucius), white-faced ibis (Plegadis chihi), ferruginous hawk (Buteo regalis), long-billed curlew (Numenius americanus), and North American wolverine (Gulo luscus) as federally listed threatened, endangered, and candidate species that may occur within the project's area of influence. Federal candidate species are sensitive wildlife species currently under consideration by the USFWS for addition to the threatened or endangered species lists. While there are no federal legal requirements to protect and/or avoid impacts to candidate species, the USFWS recommends avoiding such impacts to minimize potential economic loss or delay through project modification if the species is later listed or becomes proposed for listing during the planning process.

Peregrine Falcon

The peregrine falcon, a federal and state endangered species, is an active breeder in the vicinity of the Study Area. An inactive eyrie exists at Chimney Rock, approximately 2.5 miles east of the Study Area boundary. This nest site, the first authenticated one in the state (Bailey and Niedrach 1946), has gone unused for the past several years, possibly due to the high numbers of great horned owls at the site (Cook, personal communication, 1989; Fentzlaff, personal communication, 1989). Birds from the site formerly hunted over the Piedra River among other areas. Colorado Department of Wildlife (CDOW) Wildlife Resource Information System (WRIS) maps (on file at USFS Pine District Office, Bayfield) delineate a hunting range around the eyrie that approached the eastern bank of the Piedra River but did not overlap the Study Area. The CDOW makes a distinction between peregrine falcon "hunting range," where Chimney Rock birds are hunted most of the time, and "overall range," where hunting also occurred with less frequency. Based on the excellent hunting opportunities that exist along the river, it is likely that the Chimney Rock peregrines are frequently hunted along the river and over that portion of the Study Area flanking the river (Figure 3-8). Although peregrines do not presently nest at Chimney Rock, inclusion of the Piedra River within the "hunting range" of the former pair is appropriate from the perspective of maintaining the viability of the Chimney Rock eyrie.

An active peregrine falcon eyrie, north of U.S. Highway 160 along the Piedra River, fledged three birds in 1989. Although most hunting by these birds probably occurred within three miles of their nest, they could easily have moved 12 or more miles downstream to hunt over the portion of the Study Area which flanks the Piedra River (Craig, personal communication, 1989; J. Enderson, personal communication, 1989).

The eastern periphery of the Study Area is within the "overall range" of the inactive Chimney Rock eyrie and may be hunted by birds from the active Piedra nest. However, potential nesting sites are limited in the Study Area. Dave Cook (personal communication, 1989) reported the head of Ignacio Canyon offered possible nesting habitat. Gerry Craig (personal communication, 1989) surveyed the HD Mountains in 1988, found "no significant nesting cliffs," and concluded that the area did not provide "good nesting habitat." Jim Enderson (personal communication, 1989) knew of no peregrine nests or suitable nesting habitat in the HD Mountains.

Bald Eagle

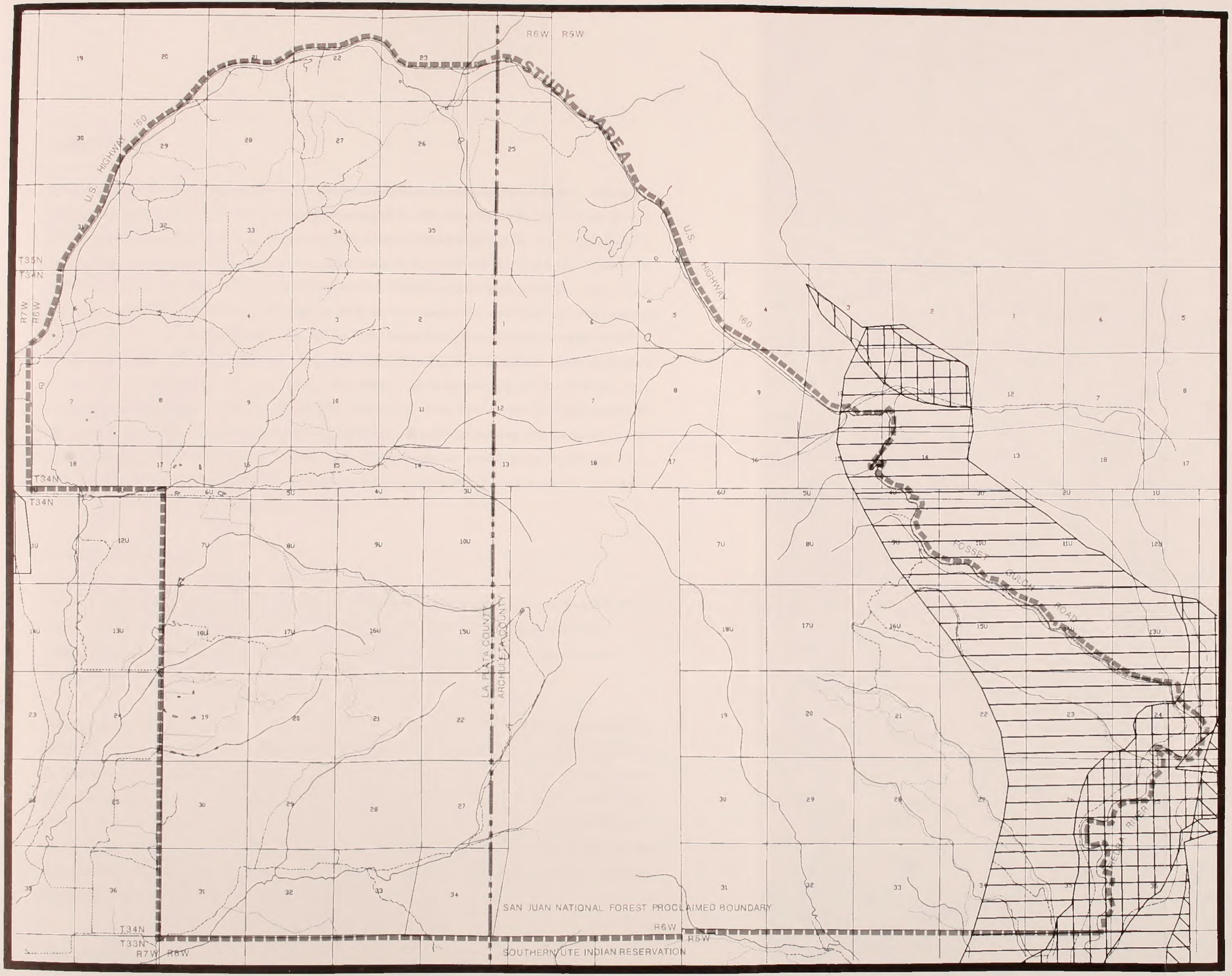
Bald eagles are federal and state endangered winter residents in the area surrounding the Study Area. CDOW WRIS mapping identified bald eagle winter ranges and winter concentration areas along portions of the Pine and Piedra Rivers, and some of their tributaries (Figure 3-8). These rivers serve as corridors where eagles move up and down to fish open areas and to hunt waterfowl. These corridors generally include a minimum of one-half mile on each side of the river. The only portion of the Study Area overlapped by WRIS bald eagle winter range is the eastern periphery, which flanks the Piedra River. Dick Fentzlaff (personal communication, 1989) and John Castellano (personal communication, 1989) have both reported low numbers (one or two birds) of bald eagles, opportunistically roosting in the relatively broad cottonwood stands flanking the river in the southeastern part of this area. No active bald eagle nests are known to be within the project's area of influence (the project area plus a surrounding zone that could also experience the influence of project-related activities). In 1987, a pair nested in a cottonwood near Navajo Reservoir and fledged two young, but they haven't returned and the nest has fallen down (Fentzlaff, personal communication, 1989). The closest active nest is located approximately 27 miles to the northwest (Craig, personal communication, 1989).

Bald eagle use of the Study Area is restricted to low numbers of winter residents that hunt the Piedra River, and which frequently leave the winter concentration areas along the Pine and Piedra rivers to scavenge big game carrion, road-killed wildlife, and possibly to hunt lagomorphs (rabbits and hares) on the lower elevation winter ranges of the HD Mountains. Low numbers of individual bald eagles are often observed in Sauls and Spring Creeks during the winter (Carron, personal communication, 1989).

Black-Footed Ferret

Black-footed ferrets are a federal and state listed endangered species that depend upon prairie dog (Cynomys spp.) colonies as a source of food and shelter (Hillman, 1968; Henderson et al. 1969; and Linder et al. 1982). All active prairie dog towns, or complex of towns, large enough to support ferrets are considered potential black-footed ferret habitat (Clark et al. 1983; USFWS 1989). However, changes in land use practices and poisoning programs over the last century have reduced prairie dogs to one-seven hundredth of their former distribution (Fagerstone, personal communication, 1989). The only known extant ferret population, before ferrets were taken into captivity, was near Meeteetse, Wyoming. However, there may still be remnant populations in parts of their historic range (Clark et al. 1983). The HD Mountains Study Area occurs within the general historic range of the black-footed ferret (Bissell 1978a), although no black-footed ferret sightings have been confirmed in Colorado in recent years.

The western half of HD Mountains Study Area supports a few small, widely separated colonies of Gunnison's prairie dogs (C. gunnisoni). Under current black-footed ferret guidelines (USFWS 1989), surveys for ferrets are required for federal projects that impact black-tailed (C. ludovicianus) or white-tailed (C. leucurus) prairie dog towns or complexes greater than 80 or 200 acres, respectively. However, because the delineation of all prairie dog towns within the Study Area was beyond the present scope of work, it is unknown if a town or complex larger than 80 acres occurs in the Study Area or if any portion of that town or complex would be affected by the proposal. Surveys would also be required if a small town within the Study Area disturbed by the proposal were part of a complex mostly outside the Study Area. If ferret surveys are required, they should occur within one year of the proposed action. It is unlikely, however, that black-footed ferrets are present in the Study Area because the few, small, widely dispersed towns in the area appear to provide an inadequate prey base.



THREATENED AND ENDANGERED SEASONAL RANGES

BALD EAGLE WINTER RANGE

PEREGRINE FALCON HUNTING TERRITORY

PEREGRINE FALCON OVERALL RANGE

SOURCE: CDOW WRIS MAPS 1989

NORTH

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 3-8

Colorado Squawfish

The Colorado squawfish is a federal and state endangered species in Colorado and New Mexico. Squawfish historically inhabited the San Juan River system downstream of the HD Mountains at the New Mexico border. No squawfish are known to presently exist above Navajo Reservoir (the Navajo dam is located approximately 30 miles downstream from the Piedra River side of the Study Area). However, a reproducing population of squawfish occurs in New Mexico downstream of the reservoir (Propst, personal communication, 1989). Adult squawfish inhabit eddies, pools, and other areas adjacent to the main current flows and move into main channel areas to feed (Haynes and Muth 1982; Woodling 1985). Diets change from primarily macroinvertebrates during the first year to fish when their total length approaches eight inches (Behnke and Benson 1980). Squawfish spawn in early to mid-summer over gravel bars in deep water. The same spawning sites are used year after year following long distance migrations (Haynes and Muth 1982). Dams have blocked spawning migrations and have prevented adults from reaching suitable spawning sites. Cold water releases from dams are thought to have eliminated some historic spawning sites as fertilized eggs would not develop in the lower temperatures (Woodling 1985). Irrigation and channelization practices have lowered summer flows and decreased backwater eddies used as nursery areas (Woodling 1985).

Mexican Spotted Owl

The northern spotted owl (Strix occidentialis caurina) is a federal threatened species and one of three subspecies of the spotted owl in the western United States. The Mexican spotted owl (S.o. lucida) is a federal candidate species and the subspecies which occurs in Colorado. The Mexican spotted owl is not present on the list of Colorado threatened and endangered species. It is addressed here because of FS concern.

There are approximately 20 historical reports of the Mexican spotted owl in Colorado (Bailey and Niedrach 1965), 13 of which are considered valid by the Colorado Rare Bird Committee. Chase et al. (1982) considered the species to be a rare migrant present in only four of Colorado's 28 latilong blocks. There were no records of this owl's presence in the Durango latilong block, which overlaps the Study Area (Chase et al. 1982). However, Gilman (1907) reported two in adjacent La Plata County in 1906, and the owl was considered a migrant in the adjacent Cortez latilong block (Chase et al. 1982). There are no verified nesting records for the state, but the owl is considered a resident of Mesa Verde National Park (Davis 1969) and juveniles have been observed in the park (Colorado Field Ornithologists 1988).

Based on the limited number of spotted owl records in Colorado, little is known of their distribution and habitat use. Recent surveys in Arizona, New Mexico, and Utah (Ganey et al. 1988) have found the owl primarily in canyons or on steep mixed conifer, mixed broadleaf, and, to a lesser extent, on spruce-fir slopes, ranging from approximately 3,300 to 9,800 feet. Reynolds (1989) surveyed 180 miles of transect in southwestern Colorado for spotted owls in 1989. Seven spotted owls were located: three in mountain or mixed-conifer forests on steep slopes and four in steep-walled mountain and piñon-juniper canyons. One of these locations was in Sandoval Canyon, approximately six miles southeast of the Study Area on Southern Ute Indian Reservation land. Habitats at the site were mountain and piñon-juniper forests on steep slopes.

Results of Reynold's (1989) surveys and behavioral characteristics of the spotted owl suggest that the species is more common in Colorado than indicated by historical records. The species is nocturnal and roosts during the day in forested canyons or on steep slopes where it is rarely seen. Most species of strictly nocturnal owls are only detected by vocalizations made during the late winter-spring breeding period. Unless specific nocturnal surveys are conducted in an area, biologists rarely know whether a particular species of owl is present. Despite the number of owls recently identified by Reynolds (1989), the species is uncommon in Colorado. Based on the number of owls located in an estimated portion of suitable habitat, there may be approximately 20 spotted owls in Colorado, including only five to six territorial pairs (Reynolds, Personal Communication, 1989).

The steep mixed-conifer and mountain slopes, as well as canyons in the HD Mountains, provide habitats ecologically similar to those at other southwestern Colorado sites occupied by the spotted owl. Reynolds (Personal Communication, 1989) did not survey the HD Mountains in 1989; however, he considers the area good spotted owl habitat. Without further study, the aforementioned Study Area habitats can be considered potentially suitable for the spotted owl. It is possible that spotted owls are present in the Study Area. A study is currently being conducted to determine if the Mexican spotted owl is present in the HD Mountains. Ongoing surveys have not detected the species (Bell, personal communication, 1989).

Ferruginous Hawk

Ferruginous hawks are a federal candidate species and a Colorado species of "special concern" (Webb 1985). This buteo is most commonly associated with native or relatively undisturbed western plains where it hunts small rodents, especially prairie dogs and ground squirrels, lagomorphs, and other prey. Call (1978) considered this species to be the most adaptable of any raptor in the selection of nest sites, which range from ground nests to tree nests to a wide variety of man-made structures. Ferruginous hawks are considered winter visitors in

the Durango latilong block (Chase et al. 1982), the approximately 3,000 square mile area between 107° to 108°W longitude and 37° to 38°N latitude which includes the Study Area.

No ferruginous hawks were noted during the brief field surveys through the Study Area (June 26 to 28, 1989), nor have any nests been reported in the area. Because this species is typically associated with open grasslands, the western third of the Study Area offers the most suitable habitat; the eastern two-thirds of the Study Area is primarily mountainous and forested with closed canopies, although relatively large open grasslands are locally available (e.g., in the extreme southeast corner of the Study Area near the mouths of Ignacio, Goose, and Turkey Creeks). The suitability of the western third of the Study Area for ferruginous hawks is, however, uncertain. Most of the former sagebrush/grasslands in this area have been converted into pastures and irrigated hayfields. With this agriculturization, burrowing mammal communities, an important prey species, have been reduced by control programs. If the seasonal presence of the species is indicative of habitat suitability, the widely scattered prairie dog towns, lagomorph, small mammal populations, and carrion would apparently constitute an adequate winter prey base. The lack of breeding ferruginous hawks in the San Juan Basin may be more reflective of their low summer numbers in the area, since such areas appear to offer habitats as suitable as other areas in Colorado where they are common breeders.

Long-Billed Curlew

This largest member of the North American sandpiper family once nested throughout western and midwestern grasslands. It disappeared from many areas because of habitat losses resulting from plains and prairies plowed for agricultural purposes (Terres 1980). This federal candidate species and Colorado species of special concern (Webb 1985) is considered a migrant in the Durango latilong block (Chase et al. 1982); there are no records of nesting in the area. Bailey and Niedrach (1965) indicated that while this species was (and still is) a summer resident and migrant on Colorado's eastern plains, there were few west-slope records of their presence and they cited no records of breeding. During migration, curlews primarily inhabit wetlands, although some upland areas are also used. The few suitable wetlands present on the western slope of the HD Mountains and larger acreage of moist pastures offer habitat for migrating curlews. However, the relatively small area of these habitats and the apparently low numbers of curlews migrating through the area suggest that the Study Area does not represent an important stopover area for migrants.

White-Faced Ibis

The white-faced ibis is a federal candidate species and Colorado species of special concern. Throughout their range, their numbers declined precipitously in the early 1970's due to pesticides (Terres 1980). They are considered migrants in the Durango latilong block, which overlaps the Study Area (Chase et al. 1982). White-faced ibis nest in colonies, usually in large stands of bulrushes or cattails, but they have also nested in heron colonies (Bent 1926). The closest known breeding area is at the Monte Vista National Wildlife Refuge, where they are uncommon breeders (USFWS 1982; Chase et al. 1982). During migration in Colorado, they are typically associated with mudflats and the littoral zone of ponds and lakes. The limited distribution of wet spring pastures and wetland habitats in and adjacent to the HD Mountains restrict the value of the area as a stopover point for the few ibis that migrate through the area.

North American Wolverine

The wolverine is a federal candidate species and Colorado endangered species (Bissell, 1978). Wolverines reach their southern distributional limits in Colorado, are scarce in other parts of the south central Rocky Mountains (Deems and Pursley 1978; Hall 1981; Wilson 1982; and Nead et al. 1985), and were, apparently, never common in Colorado (Lechleitner 1969; Armstrong 1972). Wolverines may travel over 20 miles per day and range over large territories; male territories are as large as 772 square miles (Krott 1960; Nead et al. 1985). Males exclude other males from their territories but permit females to enter (Ewer 1973).

The CDOW initiated a wolverine project in 1978 to summarize wolverine history in Colorado and to accumulate information about their current status (Nead et al. 1985). Although the study provided circumstantial evidence that wolverine were present in Colorado, it did not identify the presence of viable populations (Halfpenny 1981; Nead et al. 1985). Researchers associated with the project believe the species still exists in the state (Nead et al. 1985). Jim Halfpenny (personal communication, 1989), leader of the CDOW study, believes that the Wolf Creek Pass area (approximately 38 miles northeast of the Study Area) is the best place in the state to find wolverines.

Circumstantial evidence accumulated during the wolverine study suggested that, from May through October, wolverines primarily occur at higher elevations from the upper mountain to the alpine (Halfpenny 1981). Beginning in November, some wolverines may start an elevational migration to the lower limits of treeline or into the oakbrush-sagebrush zone, apparently in relation to migrating ungulate herds. Halfpenny (1981)

speculated that management of ungulate winter range may benefit wintering wolverines and that the loss of winter range and reduced ungulate populations could have an adverse effect.

Wolverines have historically occurred in the vicinity of the Study Area (Armstrong 1972). Recent (within the last 20 years) unverified reports from trappers and others suggest that they may still persist in the general area (e.g., around Wolf Creek Pass and around Durango) (Halfpenny, personal communication, 1989). The HD Mountains provide winter range for deer and elk which summer in a large area to the north of U.S. Highway 160. Any wolverine(s) following these migratory herds could be attracted to the HD Mountains during big game winter range occupancy.

It is unknown, though unlikely, whether wolverines are present in the Study Area. There have been no specific surveys for them in the Study Area, nor have there been any recently reported sightings. Wolverines were apparently uncommon in the area even before the arrival of the white man and, if present, they are undoubtedly less common today. If wolverines exist in the general area and if they follow migratory ungulate herds, they may seasonably occupy the HD Mountains, although they may not be present in all years. Although their habitat requirements are poorly understood, if present, wolverines would most likely utilize the area during winter.

In addition to those species federally listed by the USFWS, several species occur or potentially occur in the project's area of influence that are threatened or endangered in Colorado or New Mexico, including the river otter (Lutra canadensis), roundtail chub (Gila robusta), and bonytail (G. elegans).

River Otter

River otters, a Colorado endangered species, are present in the Pine and Piedra Rivers and some of their tributaries as a result of CDOW transplants. Otters were formerly known from every major drainage in the state before being extirpated by beaver trapping and water pollution incidental to early mining efforts (Bissell 1978c). Habitat requirements include major waterways and lakes open year-round with minimum flows of around 10 cubic feet per second (cfs). Habitats must have high water quality and contain an abundant supply of fish, amphibians, and crustaceans. The rivers and streams identified through CDOW WRIS mapping are considered "critical" habitat. Colorado designated "essential" or "critical" habitat is defined as any geographic area that is absolutely necessary for the maintenance or recovery of a threatened or endangered species (Torres et al. 1978).

The identified overall range of critical otter habitat meets the Study Area at the interface along the Piedra River. However, no tributaries of the Piedra River drainage in the HD Mountains are known to support otters, and the Study Area per se does not represent potential otter habitat. With the exception of Squaw and Beaver Creeks, which parallel U.S. Highway 160 along the Study Area's northern border, Study Area creeks are intermittent and do not support viable fisheries. The FS considers the entire Study Area a non-fishery area (Cook, personal communication, 1989). Study area drainages are, however, tributaries of the Pine and Piedra rivers.

Roundtail Chub

Roundtail chubs are a federal "Notice of Review" species and a New Mexico endangered species (Propst, personal communication, 1989); they have no special status in Colorado. Roundtails occupy slow moving waters adjacent to areas of faster river waters. Young-of-the-year prefer shallow river runs while juveniles concentrate in river eddies and irrigation ditches (Valdez et al. 1982; Wiltzius 1978). Spawning occurs over a gravel substrate in early summer as spring runoff is subsiding (Valdez et al. 1982). Coldwater releases from reservoirs may have adversely affected roundtail reproduction by delaying or eliminating spawning and by reducing development of fertilized eggs (Woodling 1985).

Roundtails have historically been collected in the San Juan River above Navajo Reservoir (Woodling 1985), and they were also found in the Reservoir shortly after dam closure (ca. 1962-63) (Propst, personal communication, 1989). One roundtail, approximately 12 inches long, was caught in Navajo Reservoir by a fisherman in 1979 (Japhet, personal communication, 1989). David Propst (personal communication, 1989) and Mike Japhet think the species probably still occurs in some of the reservoir's tributaries; however, Mike Japhet (personal communication, 1989) does not recall catching any in surveys of Navajo Reservoir tributaries.

Bonytail

The bonytail is a federal and Colorado endangered species. This fish was historically found throughout the Colorado River drainage, but is now rare in Colorado (Miller et al. 1982). One of the last specimens taken in the state was collected in 1984 from the Colorado River west of Grand Junction. The species prefers eddies and pools, not swift current (Vanicek and Kramer 1969). Lower water temperatures (resulting from reservoir releases) and hybridization have led to the decline of the bonytail (Woodling 1985). There is no evidence (museum records or survey results) that the bonytail ever existed in the San Juan River (Propst, personal

communication, 1989), although this river was probably within its historical distribution (Langlois 1978). The draft bonytail recovery plan, recently issued by the USFWS, will consider portions of the San Juan River in Colorado and New Mexico as possible recovery sites for the species if suitable habitats are located. The New Mexico portion of the San Juan River flows out of Navajo Reservoir. The Piedra and Pine Rivers, which flank the HD Mountains to the east and west, respectively, flow into Navajo Reservoir. The Colorado portion of the San Juan River is also a tributary of Navajo Reservoir, but is isolated from the river draining the Study Area.

3.5.3 Other Wildlife Species of Special Concern

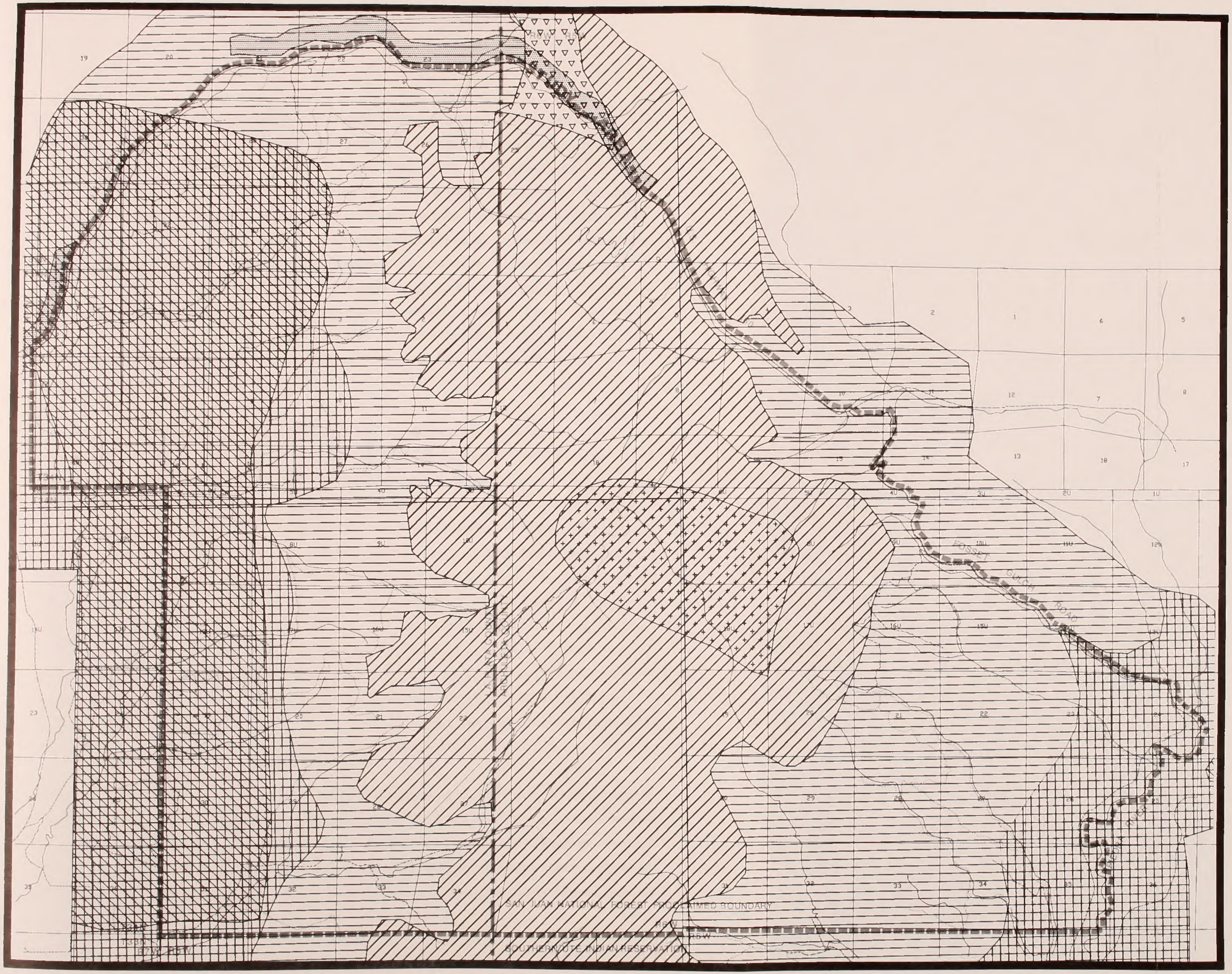
Elk

Seasonal ranges of elk (cervus elaphus) in and adjacent to the Study Area are illustrated in Figure 3-9. The Study Area supports the largest number of elk during winter, after migration from the high country north of U.S. Highway 160 funnels elk into and through the HD Mountains. Major north-to-south fall migration corridors occur (1) down Beaver Creek, into and through the Klondike Park area, and (2) into the Piedra River bottom, from east of the river and north of Chimney Rock (Figure 3-9). Some of these elk continue migrating east of the HD Mountain's divide along the Piedra River to irrigated, fertilized hayfields near Arboles. There is also a general movement into lower elevations on each side of the HD Mountains by resident elk and animals which summer north of U.S. Highway 160. The west slope of the mountains supports more extensive and better big game winter range. As mentioned above, the eastern slope is mostly closed forests and contains only 10 to 12 square miles of usable winter range (Fentzlaff, personal communication, 1989). The western slope contains a number of open canyons, more open habitat, small lower-elevation parks, and irrigated, fertilized agricultural land. Winter big-game use of these private agricultural lands is not currently excessive and is not now considered a problem. The HD Mountains are an important elk wintering area that annually supports moderate to heavy use. More elk winter on the west side of the mountains than on the east side.

CDOW WRIS mapping differentiates winter big-game habitats into "winter range," "severe winter range," and "winter concentration areas." Definitions of these ranges are provided in Appendix C-5. Elk winter range, severe winter range, and winter concentration areas comprise 59, 26, and 18 percent of the Study Area, respectively (Figure 3-9). Sixty-nine, 47, and 43 percent of these winter ranges, severe winter ranges, and winter concentration areas, respectively, occur on NFS lands within the Study Area. Winter range, totalling 34,009 acres in the Study Area, generally occurs below 7,400 feet east of the Divide and 7,600 feet west of

the Divide. In both areas, elk remain at higher elevations during milder winters and are forced down to lower winter ranges during progressively harsher winters. Severe winter range, totalling 14,962 acres in the Study Area, is generally restricted to the lowest elevations along the Piedra River east of the divide, but extends into the mouths of the canyons west of the Divide. Winter concentration areas, covering 10,501 acres of the Study Area, only occur within the Study Area along its western flank (Figure 3-9).

Approximately 30 percent of the Study Area is designated by the FS (FS 1983) as 5B (Figure 3-17), a management emphasis for big-game winter range. The area covered by this designation alone is generally consistent with the CDOW WRIS mapping, although CDOW defined winter ranges are more widespread. Another 30 percent of the Study Area is designated 4B, emphasizing the wildlife habitat needs of indicator species, including mule deer (Odocoileus hemionus) and elk. Areas designated 4B in the Study Area occur at higher elevations and generally have less value to big game as winter range, although portions of these areas are regularly used by wintering deer and elk, depending on winter severity. The remaining tracts within the Study Area are designated as 3A, 6B, and 2B, which have differing levels of compatibility with big-game winter range. Deer and elk winter ranges identified by CDOW WRIS mapping overlap approximately 85 percent of these three latter-designated areas.



ELK AND MULE DEER SEASONAL RANGES

ELK RESIDENT POPULATION

ELK AND MULE DEER HIGHWAY CROSSING

ELK AND MULE DEER SUMMER RANGE

ELK AND MULE DEER SEVERE WINTER

ELK AND MULE DEER WINTER CONCENTRATION

ELK AND MULE DEER WINTER RANGE

MULE DEER WINTER RANGE

SOURCE: CDOW WRIS MAPS 1989

NORTH

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 3-9

Spring migration off the Study Area to higher elevations and to the north generally reverses fall patterns. Some elk migrating north from the Arboles area probably remain in the HD Mountains, while others move up both sides of the Piedra River to summer ranges north of U.S. Highway 160. Bulls generally move directly to summer ranges, while cows and yearlings move to calving grounds at the lower elevations of their summer range. Specific calving grounds of the Pargin Mountain herd have not been identified (Carron, personal communication, 1989). However, by definition, some calving must occur in the headwaters of Ignacio Creek, since it is delineated by CDOW WRIS mapping as a resident elk population area (Figure 3-9) (Appendix C-6). Favorable calving habitat is probably not limited in the area due to the low number of elk suspected to be present, and is probably dispersed throughout the Study Area below spring snowlines. Summer range occupies 23,123 acres (41 percent of Study Area) at upper elevations of the HD Mountains. Ninety-five percent of this summer range is on FS land. Summer range extends south into the Southern Ute Indian Reservation and north of U.S. Highway 160.

The Study Area contains portions of CDOW Game Management Units (GMU) 751 and 771. The boundary between the two GMUs runs along the north-south divide of the HD Mountains. GMU 751 is west of the divide and GMU 771 is east of the divide. Elk are annually hunted in the area during archery, muzzleloading, and the three combined rifle seasons. Seasons generally extend from late August to early November. The Study Area receives moderate-to-heavy hunting pressure, depending on season and weather. Major hunter access roads on the west side are Spring Creek, where hunters can drive to the top of the range, and Sauls Creek. Direct public access to intervening canyons (Armstrong to Green Canyons) is restricted by private property. Hunter access on the east side is primarily off the Fosset Gulch Road with secondary access up Bull and Turkey canyons. A limited number of hunters occasionally access Ignacio Creek via Southern Ute Indian land. Hunter harvest on the east side is slightly less than average for the GMU (Fentzlaff, personal communication, 1989), while harvest on the west side is above average for the GMU and the state (C. Carron, personal communication). Hunter success in both GMUs, as in the rest of the state, is weather-dependent, with harvests increasing in years with greater fall snowfalls. The result of this hunting pressure is thought to drive elk (and deer) to lower elevations (Carron, personal communication, 1989).

There are no unusual elk management problems in the HD Mountains, primarily because of herd size and the amount of range available (Carron, personal communication, 1989). Some poaching occurs, a low number of elk are killed on peripheral highways, and firewood and Christmas tree cutting briefly displaces elk from local areas. Gas well development in Sauls Creek, during the mild 1988/89 winter, is thought to have displaced elk (and deer) into Armstrong Creek where they caused damage to pastures and fences (Carron, personal

communication, 1989). The CDOW paid the resulting game damage claims. Limited snowmobile use that now occurs in the area, resulting in the displacement of deer and elk from winter ranges, has been terminated south of U.S. Highway 160 by the FS Travel Management Map issued in 1989 (available at FS offices, FS 1989).

Elk numbers in Data Analysis Unit (DAU) 31, a large area of which the HD Mountains represents only about 5 percent, have been relatively stable at around 10,300 animals for the last 10 to 15 years (Skiba, personal communication, 1989). The last severe winter for elk was 1978/79. The current management direction is to maintain the herd at present levels.

Mule Deer

Seasonal ranges of mule deer are illustrated along with those of elk in Figure 3-9. Deer are more abundant in the Study Area on a year-round basis than elk, but their seasonal ranges and migration patterns are similar. As described for elk, the Study Area and surrounding land are most important to deer as winter range. The area, particularly lower elevations on the western side, provides winter habitat not only for resident deer, but also for large numbers of deer that summer in the high country north of U.S. Highway 160 and migrate into the area each November-December. The HD Mountains represent an important deer winter range that supports moderate to heavy use. More deer are present in the area during winter than summer, and more deer winter on the western slope of the mountains than on the east side.

CDOW WRIS polygons of mule deer "winter range," "severe winter range," and "winter concentration areas" are virtually identical to those delineated for elk, representing 60 percent (34,009 acres), 26 percent (14,962 acres), and 18 percent (10,500 acres) of the Study Area, respectively (Figure 3-9). Delineated winter range generally occurs below 7,400 feet east of the Divide and 7,600 feet west of the Divide. However, deer cannot negotiate deep snows as easily as elk, so deer often winter at slightly lower elevations (or in areas with shallower snow) than elk, particularly during harsh winters. Severe winter range and winter concentration areas occur at lower elevations of the overall winter habitat. Severe winter range only occurs within approximately one mile of the Piedra River on the east side of the Study Area, but is widespread on the west side (Figure 3-9). All 16.4 square miles of deer winter concentration area occurs along the western flank of the Study Area. Fifty-seven percent of the concentration area within the Study Area is on NFS lands.

Deer migration to and from these winter ranges typically occur from one to three weeks prior to fall elk migration and just after spring elk migration. Relative to other Colorado highways, deer road-kill mortality

on roads surrounding the Study Area is low-to-moderate as described in the Highway Mortality section. Moderate numbers of deer are killed along U.S. Highway 160 where the road crosses major migration corridors and passes through deer winter range (Figure 3-9). Fawning habitat is not limited and it is thought that fawning occurs throughout mid-to-upper elevations of the Study Area in suitable habitats.

Deer management in the HD Mountains is fairly typical of most rural districts in Colorado. Hunting pressure, harvest, and success was discussed under the section on Elk. The general effect of hunting is that deer are pushed to unhunted areas. One remarkable management concern is the amount of deer poaching that occurs. It is estimated that from 100 to 150 deer have been poached in a single year on GMU 751, with much of it occurring in Spring Creek (Carron, personal communication, 1989).

Gas development activities have had some adverse effects on wintering deer. Gas well development in Sauls Creek during the mild 1988/89 winter displaced deer and elk to agricultural land in Armstrong Creek. The CDOW paid game damage claims for damage to pastures and fences, although most destruction was probably caused by elk. Cary Carron (personal communication, 1989) indicated that deer were displaced from the Spring Creek winter range in 1987-1988 by workover gas activity. However, the deer returned to the area when development activities ceased.

Deer numbers in DAU 30 (of which the Study Area represents only about 5 percent) have slowly increased over the last 10 to 15 years (Skiba, personal communication, 1989). The last severe winter, during which approximately 4,000 deer in the DAU died, was 1978-79. The management objective for the DAU is to allow the deer population to increase approximately 18 percent (3,500 deer) over present numbers (approximately 20,000 deer).

Highway Mortality

Big game road-kill mortality data, collected by CDOW District Wildlife Managers (DWMs), are maintained by the CDOW for all of Colorado's federal and state highways and for many of the state's county roads. The date, species, sex, age-class, highway, county, and mileage marker are recorded for each road-kill encountered. Data presented below represent minimum numbers of road-kills because an unknown proportion of animals that are hit move away from the highway before dying undetected, and a small proportion are removed by Colorado Department of Highways personnel (frequently with snowplows).

Annual deer and elk road-kill mortality on roads (U.S. Highway 160, Colorado Highway 151, and LaPlata County Road 521) surrounding the Study Area was minimal-to-moderate between 1976 and 1989 relative to other Colorado highways. Of the three roads, the 26 miles of U.S. Highway 160, between Bayfield and Colorado Highway 151, annually have the highest big game mortality of any road in or adjacent to the Study Area. CDOW data for this length of highway were available from January 1976 to May 1989. For the 13 complete years, deer and elk mortalities averaged 44.8 $\pm$ 5.48 (mean $\pm$ standard error) and 7.3 $\pm$ 1.86 animals/year, respectively, ranging from 19 to 85 deer/year and 1 to 25 elk/year. The number of reported mortalities along this stretch of road varies between years and there are no apparent trends in annual deer and elk mortalities.

Deer mortality was highest during November, October, December, and April, the months of hunting, migration, and early winter range occupancy. Mortality during these four months, ranging from an average of 7.8 deer in November to 5.3 deer in April, represented 58 percent of the annual mortality. Deer mortalities were lowest in June through September when road-kills averaged 0.92 animals/month (range 0.77 to 1.2 deer/month).

Elk mortality along Highway 160 was highest during the period of migration and winter range occupancy, November through March. Mortality during these five months averaged 1.2 animals/month and represented 84 percent of the total annual road-kill. For the 13 years between 1976 and 1988, no road kills were recorded in June through September when elk are at higher elevations in their home ranges.

The highest concentrations of road-killed deer and elk occur where roads cross major migration corridors and run through winter ranges (Figure 3-9). Three elk and mule deer highway crossings, defined by the CDOW WRIS mapping as the area where more than six highway mortalities occur per mile of road per year (Appendix C-6), occur along Highway 160. Elk and, especially, deer road-kill mortalities occur along the entire length of U.S. Highway 160 that runs through the Study Area.

Annual deer and elk road-kill mortality along 34 miles of Highway 151 between Ignacio and Highway 160 is relatively low. Twelve years of CDOW data were available for this portion of highway, from January 1976 to December 1987. Annual deer and elk highway, mortality for the road averaged 17.4 $\pm$ 3.4 and 1.1 $\pm$ 0.48 animals/year, respectively, and ranged from 1 to 39 deer/year and 0 to 6 elk/year. There has been no discernable trend in the number of annual elk mortalities; however, deer mortality has shown a slight increase over the 1976-1987 period. Deer mortality was highest in January and December (mean of 3.9 deer/month), declining to lower levels during migration and early and late winter range occupancy in November, February,

and March (mean of 22 deer/month). Deer road-kills during the seven months of April through October accounted for only 19.4 percent of the total annual road-kill and was lowest from May to July. Thirteen elk were killed by vehicles on this section of highway between January 1976 and December 1987. Nine of these elk were killed on the nine miles of road immediately south of that portion of Highway 160 that is adjacent to the Study Area. Eight of these road-kills occurred in November, December, and January.

Frequency of road-killed deer on La Plata County Road 521 between Ignacio and Bayfield is extremely low. Only five deer were reported killed along this section of road between August 1972 and 1983. It is likely the June 1983 mortality was the last mortality reported (not necessarily the last mortality that occurred).

Black Bear

Little specific data on black bear (Ursus americanus) use of the HD Mountains is available. There have been no bear studies or published reports for the area. No seasonal bear habitats were delineated in the CDOW WRIS mapping because not enough was known about bear habitat use to identify specific areas. Information below is based on the experience of the CDOW DWMs whose jurisdictions cover the Study Area. Cary Carron's jurisdiction runs west from the HD Mountains divide between the Los Piños and Piedra Rivers (GMU 751) and Dick Fentzlaff's district runs east from the divide (GMU 771).

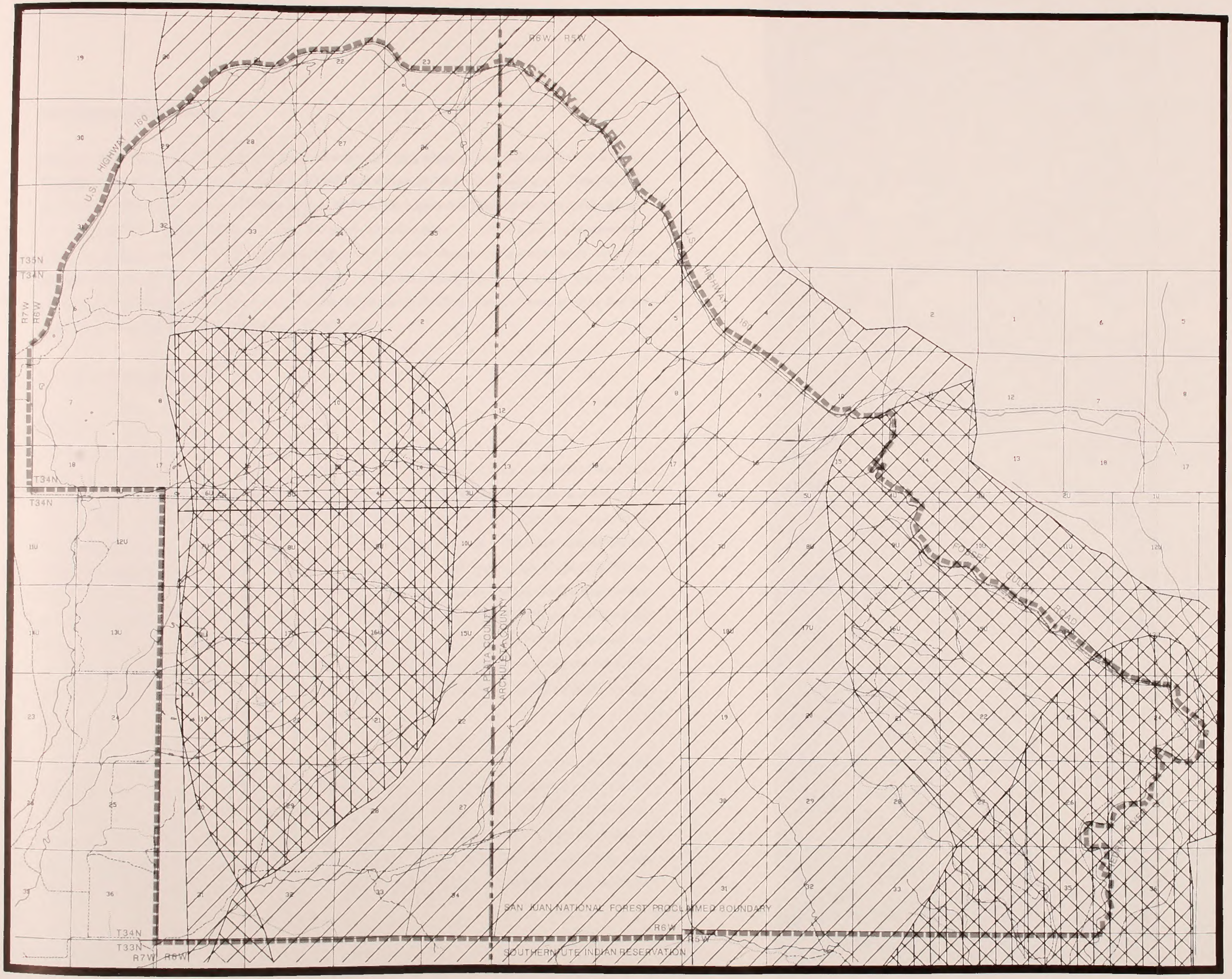
Cary Carron (personal communication, 1989) considers the entire HD Mountains area to be critical bear range because of (1) extensive oakbrush concentrations, (2) the importance of acorns to bears, and (3) the concentrations of bears that occur in oakbrush areas. Oakbrush distribution is widespread throughout the Study Area, but is most continuous on the west side of the divide. Areas supporting abundant acorn, berry, and/or other mast crops can seasonally support high densities of bears, which may migrate from a large surrounding area to exploit the resource. Areas supporting abundant fall acorn and berry crops probably represent the most important seasonal bear habitat. It is in these areas that bears accumulate much of the fat they will need during hibernation. Fat reserves also have important implications to reproductive success the following spring. Fall and spring bear densities are thought to be highest west of the divide because of mast abundance and because the west side also provides better spring bear habitat (Carron, personal communication, 1989; Fentzlaff, personal communication).

Average annual bear harvest is approximately four to six animals, with higher numbers taken on the west side and virtually all bears taken in the spring. Peak harvest on the west side (GMU 751) was 13. Harvest and mean age of bears have been declining in recent years. These are symptoms of over-exploitation.

Wild Turkey

Ninety-two percent (52,452.3 acres) of the Study Area is classified as wild turkey (Meleagris gallopave) overall range by the CDOW (Figure 3-10). This classification covers areas where turkeys have been observed in the recent past and are widespread on land outside the Study Area. Wild turkey winter range and winter concentration areas occur on the lower elevation and the eastern and western slopes of the HD Mountains and occupy 32 percent and 12 percent (18,353.9 and 7042.9 acres) of the Study Area (Figure 3-10), respectively. Definitions of these ranges are provided in Appendix C-6. Seventy-six percent of the winter range occurs on NFS lands. No critical turkey habitat occurs within the Study Area.

Wild turkeys have recently been increasing their numbers in the Study Area, possibly resulting from a recovery from Mycoplasma sp. (a bacterial disease) which had formerly reduced their numbers (D. Fentzlaff, CDOW, personal communication). Although there are no accurate estimates of population size, both DWMs indicated that flocks have been increasing and expanding their ranges. In the last two years, turkeys have been wintering in Zabel, Ritter, and Armstrong canyons. These birds are thought to have come from flocks on the east side of the HD Mountains (Carron, personal communication, 1989). Thirty-four birds were released by the CDOW in Ritter and Armstrong Canyons in January-February, 1989 as a supplemental transplant. Habitats heavily utilized in the area include piñon-juniper, mountain shrub, oakbrush, and ponderosa pine. Mature ponderosa pine stands with open canopies are used as turkey roost trees and are an important habitat component. Suitable stands are limited, particularly on the west side of the Study Area. Logging, road-construction, and energy extraction have reduced the number and suitability of roosting sites.



WILD TURKEY SEASONAL RANGES

- WILD TURKEY OVERALL RANGE
- WILD TURKEY WINTER CONCENTRATION
- WILD TURKEY WINTER RANGE

SOURCE: CDOW WRIS MAPS 1989

NORTH

1/4 0 1/2 1 2

MILES

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FIGURE **3-10**

Management Indicator Species

Elk, mule deer, black bear, wild turkey, hairy woodpecker (Picoides villosus), and green-tailed towhee (Pipilo chlorurus) were selected by the FS as management indicator species (MIS) for the Study Area. These MIS are those that are commonly hunted in the Study Area, or those whose habitat requirements and population changes are believed to indicate effects of management activities on a broader group of wildlife species in the ecological community. The first four species are discussed above. The hairy woodpecker is a primary cavity nester and was selected as an indicator of mature forested habitats. The green-tailed towhee is a ground-feeding sparrow selected as an indicator of mountain shrub and oakbrush habitats in the Study Area. No quantitative data are available for either of these latter species in the Study Area.

3.5.4 Other Wildlife Groups of Concern

Fisheries

Fisheries resources in the Study Area are extremely limited, primarily because drainage basins in the Study Area are relatively small and most streams are intermittent. The FS classifies the entire area as a nonfishery area (D. Cook, USFS, personal communication). The CDOW concurs that the Study Area, as defined, supports only marginal fisheries, at best (G. Skiba, personal communication). The west side of the HD Mountains drains into the Los Piños River, which flows into Navajo Reservoir just south of the New Mexico border. The intermittent eastern drainages of the HD Mountains are tributaries of the Piedra River, which flows into Navajo Reservoir approximately six miles south of the Study Area. Both the Piedra and Los Piños Rivers are considered transitional mountain fisheries. The San Juan River flows out of Navajo Reservoir and is a tributary of the Colorado River. For information on threatened and endangered fish present and potentially present downstream of the Study Area, see the individual accounts under Threatened and Endangered Species.

The Study Area extends to, but does not include, the Piedra River. However, the reach of the Piedra adjacent to the Study Area supports the largest and closest viable fishery to the Study Area. Most of the river south of U.S. Highway 160, and that portion in the Study Area, is privately owned or owned by the Southern Ute Indian Tribe and closed to public fishing. The river is regularly stocked with catchable rainbow, fingerling rainbow, and brown trout (CDOW file data). The most recent electrofishing survey, in or proximal to the Study Area, was conducted in November, 1987 on a 1,000-foot section of the Piedra River immediately below the Fosset

Gulch Road (CDOW file data). Stream width averaged 79 feet, pool:riffle ratio was 10:90, flows (unmeasured) were above normal and turbid, and netting efficiency was considered poor, although sampling was adequate. Three brown trout (Salmo trutta), three bluehead suckers (Catostomus discobolus), one white sucker (C. commersoni), 16 mottled sculpin (Cottus bairdi), and numerous speckled dace (Rhinichthys osculus) were caught. The reach was considered of poor sport fishery value and in need of habitat improvement.

Beaver and Squaw Creeks are the only Study Area streams that support even marginal fisheries. Beaver Creek, which runs along the northwest Study Area boundary, was surveyed by the CDOW in 1984. Width of the 300-feet sample section averaged 13.4 feet and the flow was an above-normal 1.56 cfs. Fifty fish representing five species were captured. Two of the fish were cutthroat trout (Oncorhynchus clarki) which averaged 7.5 inches and 115 grams. The remaining 96 percent were rough fish composed of two white suckers, 12 bluehead suckers, 15 speckled dace, and 19 mottled sculpins. Beaver (Castor canadensis) ponds are numerous along sections of this creek, which parallels U.S. Highway 160 and drains into the Los Piños River.

Squaw Creek, which flows into Yellowjacket Creek and the Piedra River from the east side of Yellowjacket Pass, is similar in form to Beaver Creek, but with a slightly steeper gradient. No fisheries surveys have been conducted in this creek, which is assumed to be a marginal fishery.

Raptors

In addition to those raptors discussed in Section 3.5.2, a number of other birds of prey also inhabit the Study Area. Golden eagles (Aquita chysaetos) and prairie falcons (F. mexicanus) hunt habitats in the Study Area, but there are no known nest sites within two miles of the Study Area boundary (CDOW WRIS data). Other raptors which reside in, or seasonally inhabit, the Study Area include the turkey vulture (Cathartes aura), one or more accipiters ((Accipiter spp.) forest hawks), the northern harrier (Circus cyaneus), rough-legged hawk (B. lagopus), red-tailed hawk (B. jamaicansis), American kestrel (F. sparverius), great horned owl (Bubo virginianus), and probably one or more species of "small" owls.

Waterfowl and Shorebirds

Waterfowl use of the Study Area is extremely limited due to the scarcity of waterbodies. However, low numbers of a variety of species, including the mallard (Anas platyrhnchos), gadwall (A. strepa), American widgeon (A. americana), teal (A. spp.), and American coot (Fulica americana), are seasonally present in the small stockponds interspersed in agricultural areas of the western Study Area.

Predators and Furbearers

Predators and furbearers characteristic of the San Juan Mountains are also present in the Study Area. Representatives include the beaver, coyote (Canis latrans), red (Vulpes vulpes) and gray fox (Urocyon cinereoargenteus), marten (Martes americana), badger (Taxidea taxus), skunks (Mephitus mephitus and Spilogale putorius), mountain lion (Felis concolor), and bobcat (Lynx rufus). There is at least limited trapping and hunter harvest on most of these species.

Nongame

Much of the data base used to describe and assess wildlife use of the Study Area was obtained from CDOW WRIS mapping or other nonsystematic surveys. However, the WRIS system primarily addresses game and threatened and endangered species and does not delineate and map the ranges or seasonal habitats for each of the several hundred nongame wildlife species that inhabit the HD Mountains. This level of data is also unavailable from other sources. As a result, while a species may be known to inhabit the area, its numbers, distribution, and use of habitat types are unknown except on a general basis. This lack of detailed site specific data, however, should not suggest that unmapped species are not important.

There have been no systematic surveys of amphibians, reptiles, nongame birds, or mammals in the Study Area. However, based on the distribution and diversity of habitats present, it would appear that the Study Area supports a rich nongame community, perhaps slightly higher than in the general surrounding area. The reason for this is simply the definition of the Study Area. Habitats in the Study Area range from the Piedra River, with its broad cottonwood stands, to arid grasslands and sagebrush-grasslands interspersed with irrigated agricultural land, through piñon pine, oakbrush, and a number of forested habitats, to a small spruce-fir zone atop the HD Mountains. Each of these habitats supports a unique assemblage of species and, collectively, a

rich wildlife community. It is unlikely that, if the same Study Area size and configuration were located elsewhere in the surrounding area, it would overlap such a diversity of relatively undisturbed habitats.

Nongame species provide a variety of ecological functions, one of which is the prey base they represent for avian and terrestrial predators. Characteristic species in the area include garter (Thamnophis elegans) and bull snakes (Pituophis melanoleucus); the common raven (Corvus corax) and Oregon junco (Junco hyemalis ssp.); piñon (Gymnorhinus cyanocephalus), Steller's (Cyanocitta stelleri), and gray jays (Perisoreus canadensis); woodpeckers, deer mice (Peromyscus maniculatus), meadow voles (Microtus pennsylvanicus), and red (Tamiasciurus hudsonicus) and Abert's squirrels (Sciurus aberti).

3.6 VISUAL RESOURCES

This section describes the visual resources of the Study Area using the USFS Visual Management System (VMS). This methodology was developed by the Forest Service for describing and managing visual resources on National Forests. It includes inventories of variety classes, sensitivity levels, distance zones, visual quality objectives, and visual absorption capability. This system is described in more detail in Appendix C-7, along with a glossary of terms. The information presented below is taken mainly from the existing visual resource inventory of the San Juan National Forest and was supplemented by field verification. An inventory of visual absorption capability in the Study Area was conducted by Woodward-Clyde Consultants, with the assistance of the FS, during preparation of this EIS. Visual absorption capability (VAC) is a measure of the landscape's ability to accept alteration without losing its inherent visual character. As described below, the Study Area contains a number of access roads and well development facilities, defined as cultural modification. Although some of these cultural modifications are visible, the majority of the modifications are absorbed by physical features inherent in the landscape and are not visually apparent. Variety class is an assessment of existing visual quality, based upon physical factors including topography, vegetation, water, and other landscape features.

Most of the Study Area is variety class B, defined as common or average scenic quality. The Study Area is located between the eastern portion of the Navajo Section of the Colorado Plateau and the southwestern corner of the Southern Rocky Mountain physiographic provinces (Fenneman 1931), and specifically, where the northern-most extension of the San Juan Basin of the Colorado Plateau meets the south central edge of the San Juan Mountains (Hurst 1956). The landscape includes a diversity of topography and vegetation. Lower elevations are covered by piñon-juniper woodland. Higher elevations are covered with Pine-Douglas Fir Forests.

Grasses and mixed shrubs are scattered between the forested areas. Some of the higher mountain peaks are etched with light-colored sandstone outcrops or rock cliffs.

Sensitivity levels are a measure of people's concern for scenic quality. It is based on the numbers and user type. Sensitivity levels are determined for land areas viewed by those who are traveling through the Forest on developed roads and trails; who are using areas such as campgrounds and visitor centers; or who are recreating at lakes, streams, and other water bodies. It is recognized that all NRS lands are seen at least by aircraft users. Therefore, some degree of visitor sensitivity will be established for the entire land base. The sensitivity level in the Study Area is primarily moderate. High sensitivity is present within 1/4 mile (foreground distance zone) along major travel routes and access roads into the HD Mountains. Most of the Study Area is located in the middleground distance zone (1/4 to 5 miles) from sensitive viewpoints.

Visual quality objectives (VQOs) are descriptions of a different degree of acceptable alteration of the natural landscape based upon the importance of aesthetics. The degree of alteration is measured in terms of visual contrast with the surrounding natural landscape. The VQOs for the Study Area (Figure 3-11) range from Retention to Maximum Modification. Retention is found mostly along U.S. Highway 160, Beaver Creek, Pargin Mountain, and the Piedra River. As identified in the Forest Plan, Partial Retention VQO is located in the northern and western portion of the Study Area. Modification VQOs are found in the remaining portions of the Study Area.

A range of high, moderate, and low VAC is present in the Study Area (Figure 3-12). A major portion of the Study Area is covered with high VAC. Because of topographic and vegetation diversity, high VAC generally occurs through the central and southern portion of the HD Mountains. Pockets of moderate VAC are scattered throughout the Study Area and along Fosset Gulch Road. The Study Area contains cultural modifications, primarily gas well pads and access roads; however, these modifications are not visually evident due to high and moderate VAC. Low VAC is mainly concentrated on the major travel routes, including U.S. Highway 160, Buck Highway (County Road 521), and entrances into Sauls Creek (County Road 527), Armstrong Canyon (County Road 523), and Spring Creek (County Road 334).

3.7 CULTURAL RESOURCES

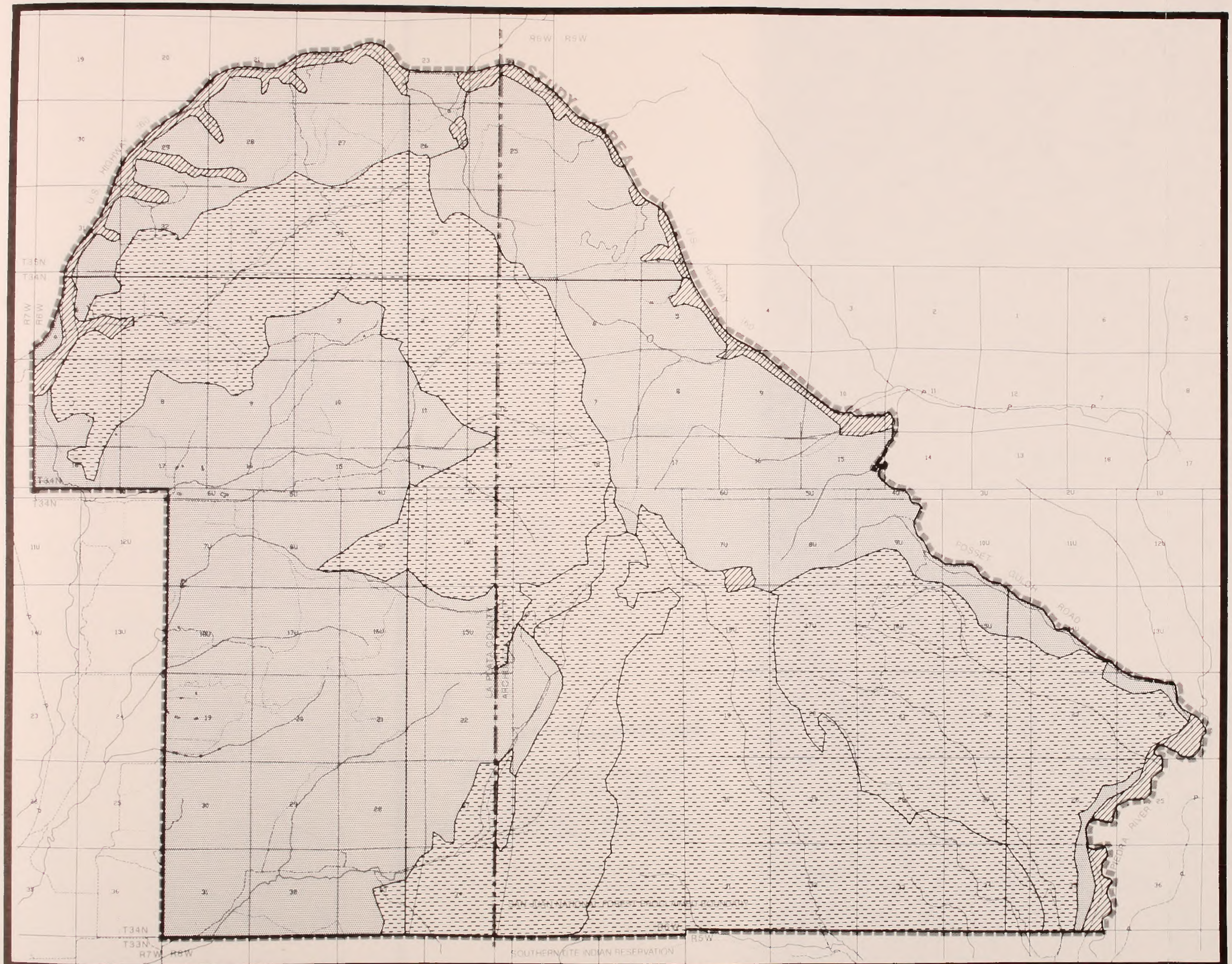
A synthesis of the available cultural resource data indicates several areas of known and projected high site-density areas scattered throughout the Study Area (Figure 3-13). For the purposes of this study, the "high" areas delineated on Figure 3-13 have or are projected to have a site-density of over 15 sites per square mile. The "medium" areas have or are projected to have a density of 5 to 14 sites per square mile, and the "low" area is defined as 0 to 4 sites per square mile. These figures are based on actual survey data including the plotted location of all known sites, and the projections of unsurveyed areas based on topographical and environmental traits shared with adjacent surveyed areas.

The surveyed areas are depicted in Figure 3-14. There have been 11,979 acres (21 percent of total Study Area) surveyed at an intensive, Class III level. Ten percent (5,684 acres) of the area was surveyed at a Class II level, leaving approximately 39,011 acres (69 percent) unsurveyed. This includes NFS land, private land, and state lands. A Class III survey indicates an intensive pedestrian survey of the entire area indicated. A high level of confidence is associated with this type of survey. A Class II designation indicates the area was not intensely surveyed but only sampled; confidence in site-density projections is only moderate. The white or blank areas on Figure 3-14 have not been surveyed, and site-density figures are projected with a low level of confidence.

Cultural resource data for the project area were compiled through an extensive review of archaeological literature, unpublished surveys, state and federal computerized site data bases, and consultation with locally experienced archaeologists. These data indicate human activity in the region dating back over at least the past ten thousand years.

The cultural/chronological framework applicable to this Study Area is detailed in Cultural Appendix C-8, along with a comprehensive cultural/historical overview. The primary chronological outline includes:

Paleo-Indian Stage	10,000-5000 B.C.
Archaic Stage	5,000 B.C.- A.D. 1
Formative Stage	A.D. 1-1450
Post-Formative Stage (Native American)	A.D. 1500-1800
Historic Period	A.D. 1600-Present



VISUAL QUALITY OBJECTIVES

- MODIFICATION
- PARTIAL RETENTION
- RETENTION

NORTH

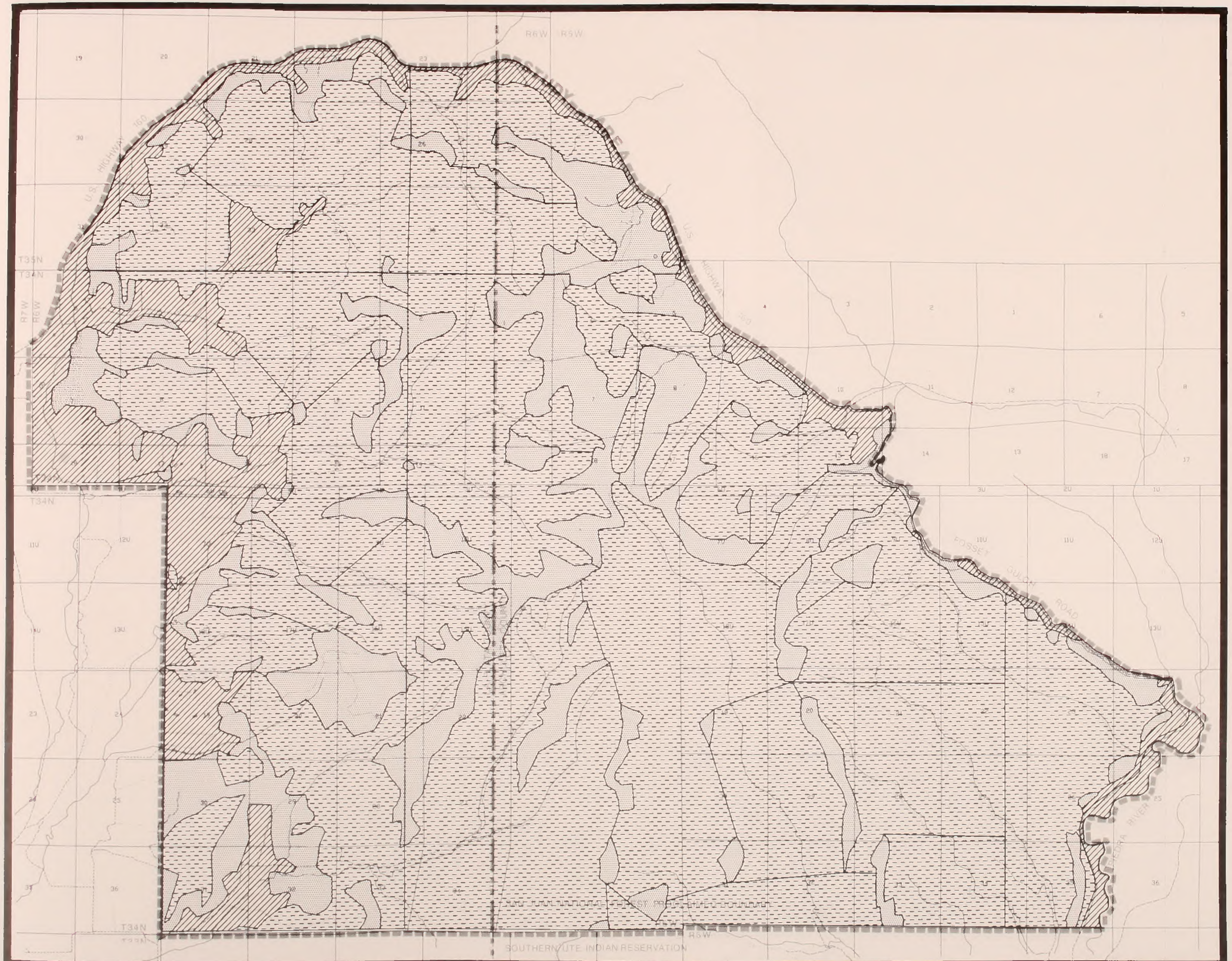
1/4 0 1/2 1 2
MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST
PREPARED BY WOODWARD-CLYDE CONSULTANTS
SPRING 1990

FIGURE **3-11**



VISUAL ABSORPTION CAPABILITY

HIGH

MODERATE

LOW

NORTH

1/4 0 1/2 1 2

MILES

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FIGURE **3-12**

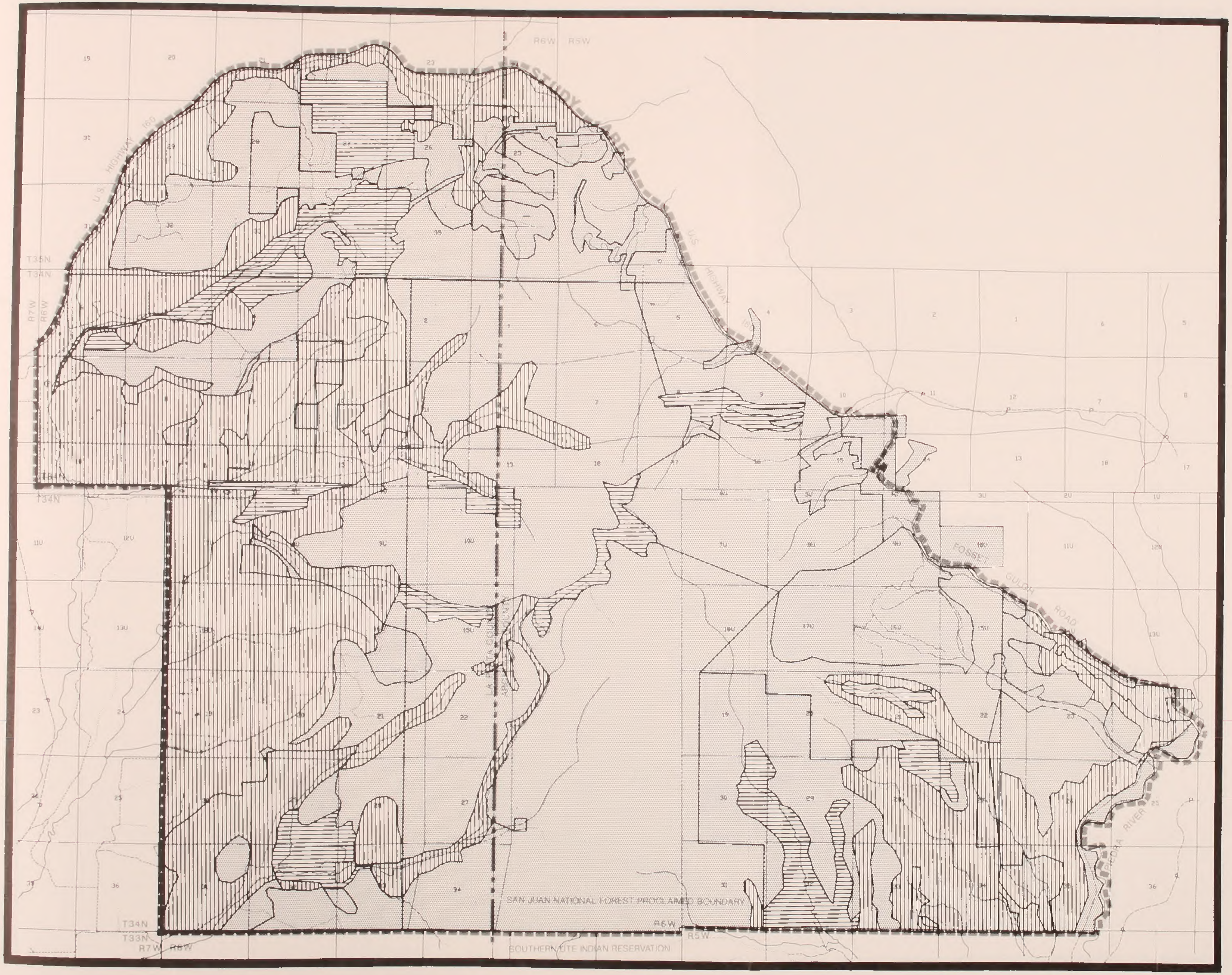

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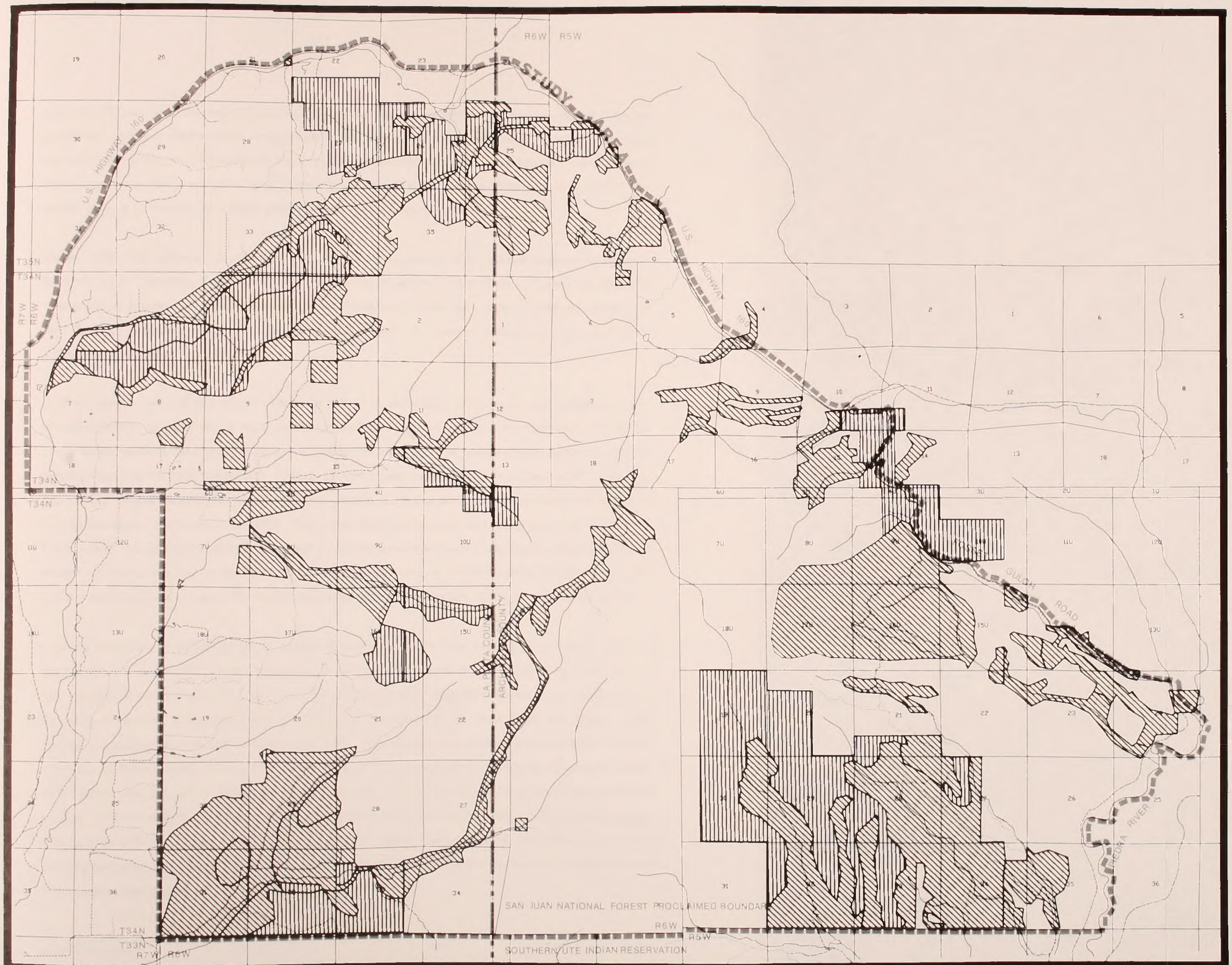
FIGURE 3-13



CULTURAL RESOURCES
LEVEL OF SURVEY

CLASS III

CLASS II

NO SURVEY

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

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FIGURE 3-14

More than 60 percent of the recorded localities in the Study Area is associated with various Anasazi Tradition periods and phases of the Formative Stage (Table 3-23). Sites of unknown (but aboriginal) cultural affiliation are the next largest group (23.8 percent). Much smaller representation of other cultural periods include historic Ute (6.2 percent), European American (4.0 percent), archaic (3.4 percent), and Navajo (1.8 percent). The earliest stage is represented by a single possible Paleo-Indian projectile point.

Review of the data indicates that substantial gaps exist in our knowledge of the cultural resource inventory of the Study Area. However, despite these gaps, it is also apparent that prehistoric use of the Study Area was as intensive as in much better known and documented Southwest regions, such as Mesa Verde to the west. In fact, the HD Mountains Study Area contains a wide variety of important cultural resources with great archaeological potential.

Cultural resource research and mitigation projects have been undertaken in the Study Area through a variety of organizations. In particular, a large number of small-scale surface surveys have been conducted by FS personnel and professional archaeologists under contract to either the FS or private businesses operating under permit on San Juan National Forest land. To date, the most comprehensive study encompassing the Study Area was a major cultural resource survey undertaken in 1984 to determine the impact of proposed coal mining in the HD Mountains (Martorano et al. 1985). Small-scale field surveys were also conducted in the western HD Mountains by Fort Lewis College at Durango and the University of Northern Colorado in Greeley. Immediately outside the Study Area, east of the Piedra River and south on Southern Ute Reservation land, the University of Colorado operated numerous surveys and excavation programs in the late 1960s through the mid-1970s.

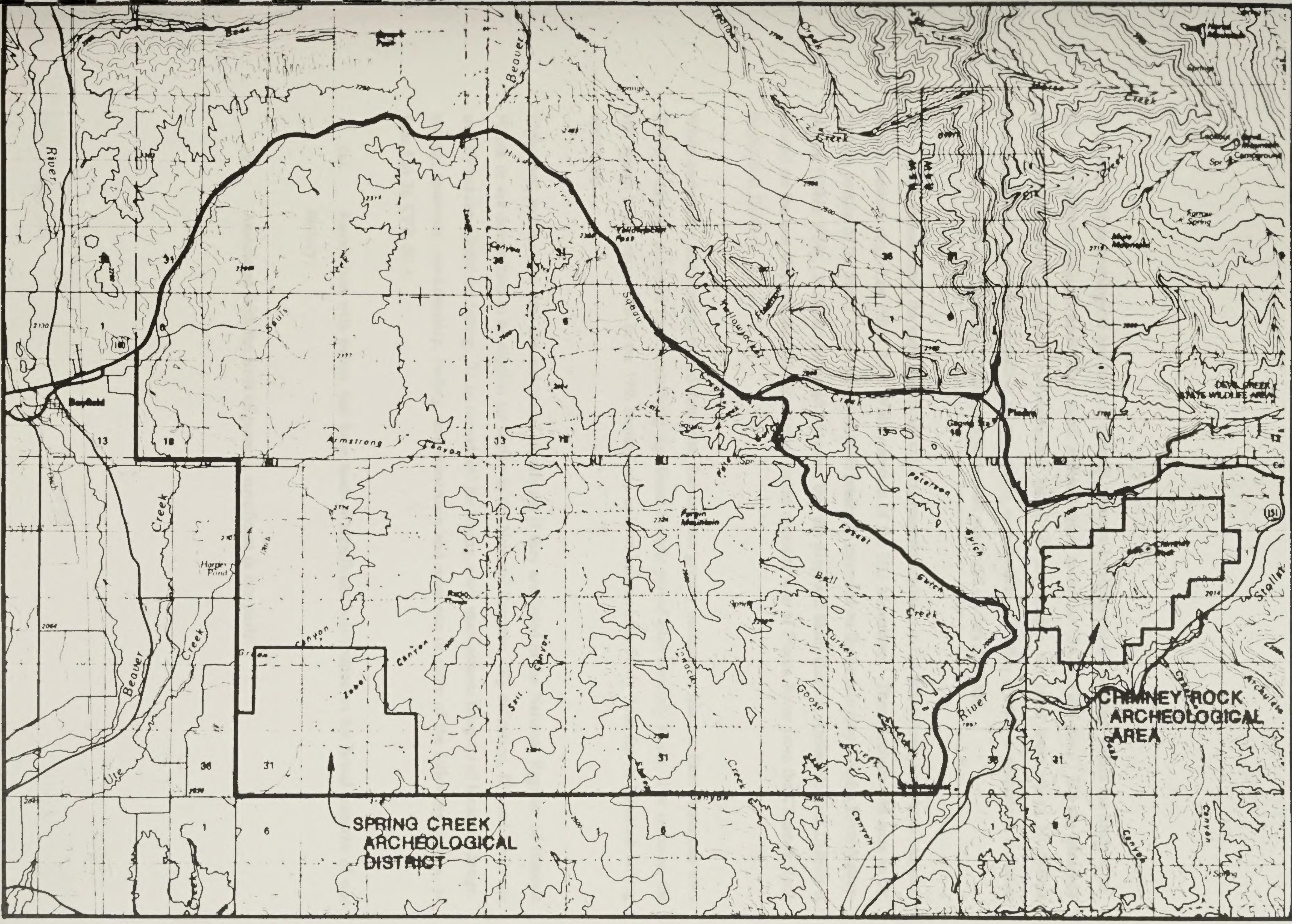
Growing awareness of cultural resource concentrations in the Study Area has led to increasing efforts at preservation and protection. These efforts have become critical in recent years with growing vandalism and "pot-hunting" of archaeological sites on both public and private land. Tangible evidence of a growing concern for cultural resource preservation and protection can be found in the creation of the Spring Creek Archaeological District, southeast of Bayfield, in 1983. Formation of two additional archaeological districts at Armstrong Canyon, north of the current Spring Creek district, and at Skull Canyon, in the southeast corner of the Study Area, has been recommended (Martorano et al. 1985: 139-143), but their establishment remains pending. Just east of the Study Area, across the Piedra River, is the well-known Chimney Rock Archaeological District (Figure 3-15). Recent San Juan National Forest cultural resource policies have been successful in avoiding and protecting archaeological sites in conjunction with on-going development of multiple national forests and natural resources.

TABLE 3-23

CULTURAL PROVENANCES OF SITES BY PERIODS AND PHASES FOR THE HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT EIS STUDY AREA

Cultural Period/Phases	Percent of Total of Sites/Components
Paleo-Indian	00.3
Archaic	03.4
Anasazi Periods/Phases	60.5
Navajo Tradition	01.8
Historic Ute Tradition	06.2
Historic European-American	04.0
Unknown Cultural Affiliation	23.8
	100.0

Source: Appendix C-6.



LOCATIONS OF IMPORTANT DESIGNATED ARCHAEOLOGICAL AREAS IN AND NEAR THE HD MOUNTAINS COALBED METHANE FIELD DEVELOPMENT EIS STUDY AREA.

Figure 3-15

At present, 448 archaeological and historic cultural resource localities are documented within the Study Area. This total includes isolated finds (IFs), small archaeological resources (SARs), and sites. IFs are generally single artifacts found in solitary circumstances, and SARs are similar but could have up to 20 objects unassociated with any structures such as rooms, earths, or pithouses. All other historic or prehistoric localities are recorded as sites. Generally, localities less than 50 years old are not recorded.

Most of the Anasazi sites, the most significant cultural resource tradition in the Study Area, have been recorded on the western slope-Los Piños River Valley-section of the HD Mountains. These include 148 sites in the western portion of the Study Area, compared to 49 presently recorded on the eastern slope-Piedra River Valley-section (Table 3-24). It should be noted however, that the proposed Skull Canyon Archaeological District is located on the east slope of the HD Mountains, on the opposite side of Piedra River from the Chimney Rock Ecological District.

While prehistoric and historic period American Indian sites greatly outnumber historic Euro-American sites (Table 3-25), the potential for encountering significant historic period sites certainly exists. For instance, the HD Ranch began operations in the 19th century and utilized much of the Study Area for its livestock raising operations.

Prehistoric and historic sites are considered significant if they are listed in the National Register of Historic Places or are determined to be eligible for listing in the National Register. By definition, IFs and SARs are usually not considered for listing. To be considered for listing, a site must possess integrity of location, design, setting, materials, workmanship, feeling, and association and meet one or more of the following criteria, as found in 36 CFR 60.4:

(a) Association with events that have made a significant contribution to the broad patterns of our history;

(b) Associated with the lives of persons significant in our past;

TABLE 3-24

ANASAZI SITE DISTRIBUTION BY PERIOD/PHASE ON EASTERN AND WESTERN FLATS OF THE HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT EIS STUDY AREA

Period/Phase	Western Slope	Eastern Slope	Percent of Total Anasazi Sites
Basketmaker II	6	1	03.55
Basketmaker III	1	0	00.05
Pueblo I/Rosa Phase	98	11	54.43
Pueblo I/Piedra Phase	13	13	13.2
Pueblo II/Arboles Phase	7	11	09.14
Pueblo II/Chimney Rock Phase	1	1	00.10
Undefined Pueblo I-II	22	12	17.26
	148	49	97.73

Source: Appendix C-7.

TABLE 3-25

RECORDED SITE TYPES IN THE HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT EIS STUDY

Site Type	Number of Sites	Percent of Total Sites
Prehistoric Single Habitation Unit with one surface living structure or pithouse/surface storage structure pairs.	48	14.82
Prehistoric Multiple Habitation Units with 2-5 pithouses with associated surface storage structures or 2-5 surface living structures.	10	03.09
Prehistoric Village Habitation Units with 6 or more pithouses with associated storage structures or 6 or more surface living structures.	5	01.54
Prehistoric limited activity sites, including homebase camps, field houses, food and lithic processing areas, hunting camps, and isolated storage facilities	251	77.47
Historic sites, including logging camps, trash dumps, and farm and ranch homesteads.	10	03.09
	324	100.01

Source: Appendix C-7.

(c) Embodiment of the distinctive characteristics of a type, period, or method of construction, or representative of the work of a master, or possession of high artistic values, or representative of a significant and distinguishable entirely whose components may lack individual distinction; and/or

(d) Have yielded, or may be likely to yield, information important in the study of prehistory.

Six sites in the Study Area are currently listed in the National Register. Archaeologists have recommended another 79 sites as being eligible for listing; however, they have not formally been determined eligible by the FS and the Colorado State Historic Preservation Officer. The 124 IFs and SARs are not eligible by definition, leaving approximately 239 sites for which no eligibility recommendations or determinations have been made. Many of these sites are probably eligible for listing in the National Register, predominantly under criterion (d) of 36 CFR 40.4.

3.8 LAND USE

Land jurisdiction and ownership within the Study Area is divided between public and private land (Figure 1-2). The majority of public land in the Study Area is under the jurisdiction of the FS. Other public land includes one isolated school section under the jurisdiction of the state (Section 16, T34N, R5W). Within the designated or proclaimed FS boundary for the San Juan National Forest are scattered parcels of private inholdings. These private lands are generally bordered by NFS land.

Land use information was compiled from maps and existing literature from public and private agencies. Data sources for the baseline inventory included interpretations from USGS 7.5-minute topographic quadrangle sheets and orthogonal photos (scale 1 inch = 2,000 feet), a San Juan National Forest Map (scale 1 inch = 2 miles), and color aerial photography. The baseline data were supplemented by information obtained from meetings with federal, state, and county planning and land managing agencies. Several of these agencies also supplied pertinent documents and maps. All data were verified by ground reconnaissance during the fall of 1989.

Land uses in the HD Mountains include livestock grazing, hunting, timber harvesting, oil and gas exploration, outdoor recreation, and tourism. Area wide (areal) and line type (lineal) land uses are distributed throughout the Study Area (Figure 3-16). Major areal uses include watershed restoration, rangeland/forest, oil and gas development, agriculture, residential, and communication facilities. The greatest area of land use is rangeland/forest used for livestock grazing and wildlife habitat. A detailed discussion of grazing activities and

the associated grazing allotments is provided in Section 3.4: Vegetation, Timber, and Grazing Resources. Some agriculture is located along Fosset Gulch and the western base of the HD Mountains. These fields are also used for livestock pasture. The Study Area contains scattered areas of existing and abandoned natural gas wells. Forty-four existing and four abandoned wells were identified on private and NFS lands in the Study Area. Some locations contain flowline systems for delivery of water and methane gas.

Types of residential areas include trailers, cabins, ranches, and farms. Most residential locations are scattered along the western portion of the Study Area along Sauls Creek, Armstrong Canyon, and Spring Creek. Other dwellings are found along U.S. Highway 160, Fosset Gulch, and the Piedra River. Two areas were identified in the Study Area with communication facilities: in the northeastern portion is an AT&T relay station, and on the ridge-top of the HD Mountains are several communication relay stations collectively occupying approximately one acre.

Lineal land uses identified in the Study Area include several gas and water flowlines, access roads, and one electrical transmission line. Segments of the Pine River/Bayfield irrigation ditch cross a portion of the NFS lands north of Crowbar Creek. Access roads are described in Section 3.9: Transportation. Gas delivery pipelines and water collection pipelines are found primarily in the western portions and, to a limited extent, in the eastern portions of the Study Area. A 115-kV electrical transmission line traverses the northern portion of the Study Area in an east-west direction.

Planned future land uses are limited primarily to oil and gas exploration and development. The FS plans to designate areas for commercial timber harvest; however, these plans are in the preliminary planning phase and are, most likely, years away from development (see Section 3.4.4).

3.9 TRANSPORTATION

The Study Area has been partially defined by the existing major transportation routes. The Study Area is bounded to the north by U.S. Highway 160. The Study Area is further defined to the northeast and east by

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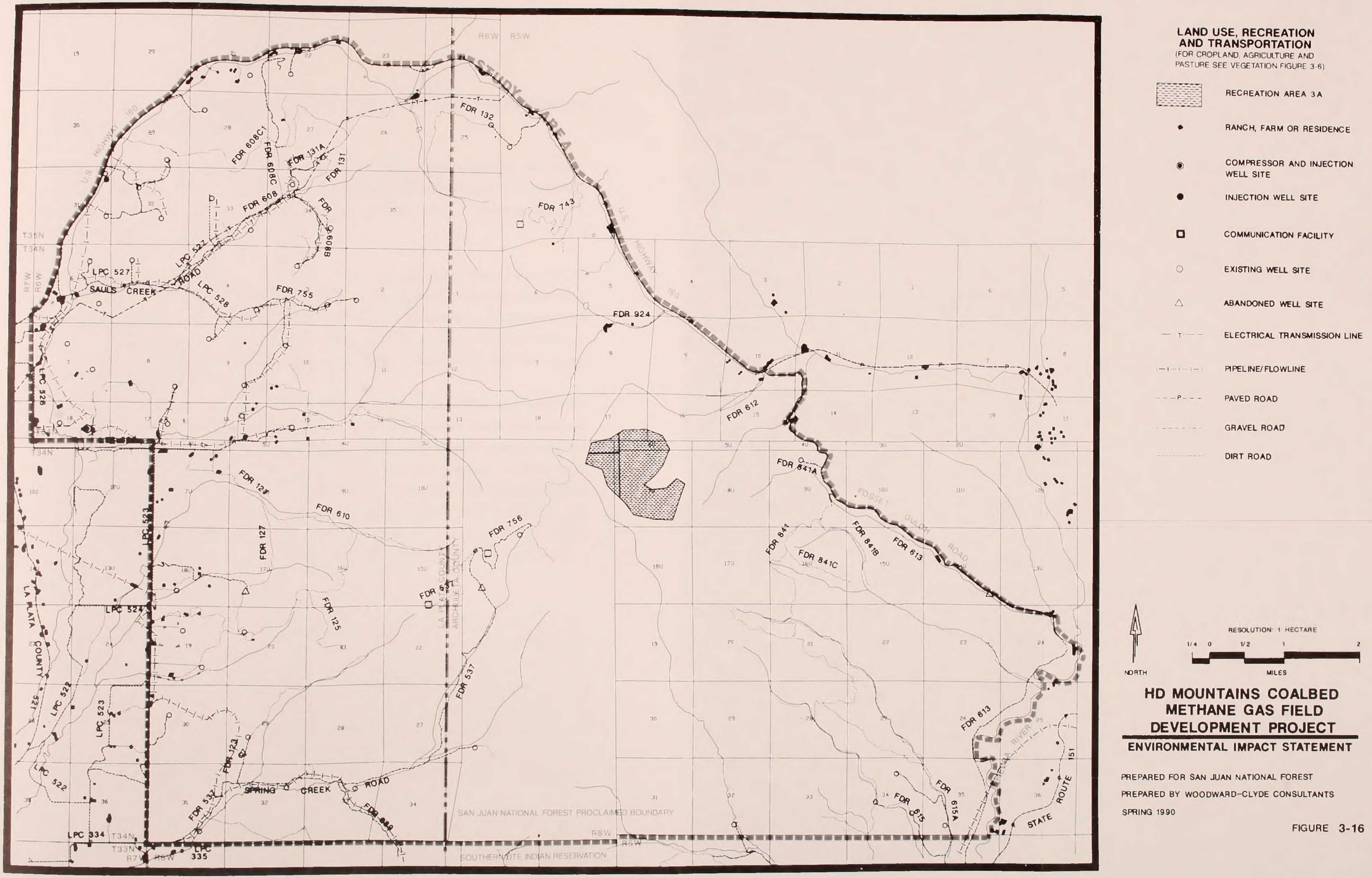

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 3-16

Forest Development Road (FDR) 613 (Fosset Gulch Road). La Plata County Road 521 (Buck Highway) and State Highway 151 define the western edge.

There are several access roads which lead into the Study Area; however, there is no access road running completely through the Study Area. To the west, major access roads include La Plata County (LPC) roads 527, 525, 522, 523, 334, and 335, and FDRs 608 (Sauls Creek) and 537 (Spring Creek); to the north are FDRs 132 and 743; and to the east is FDR 613.

The bulk of available data for transportation was compiled from discussions with and information provided by the FS Pine District, La Plata County Roads and Bridges Department, Archuleta County Planning and Road Departments, and Colorado Department of Highways. Limited field reconnaissance occurred during the fall of 1989. This information has been compiled and displayed. Figure 3-16 shows the road access network in the HD Mountains Study Area. No roads in the Study Area are under the jurisdiction of Archuleta County.

Table 3-26 identifies the access roads of the Study Area. The table includes road descriptions, average traffic volume, surface type, road condition, and the number of bridges (and associated weight restrictions) and culverts. Traffic use volume information was available from La Plata County and the State of Colorado. No traffic survey data were available from Archuleta County or the FS. Road surface types are broken down into four categories: paved, gravel, dirt, and primitive. Paved roads are defined as all-weather roads with excellent access. Gravel roads are constructed of aggregate material with designed drainage; access is rated good. Dirt roads are defined as graded native earth surface with or without drainage; access is considered fair. Primitive roads are four-wheel drive surfaces with no drainage; access is poor. Dirt and primitive roads are addressed together.

The Colorado State Highway Department prepares an annual inventory of road conditions. Road conditions are broken down into the categories of good, fair, and poor. Table 3-27, Road Condition, defines these categories in detail. Most of the county roads in the Study Area, displayed in Table 3-26, are in fair to poor condition. Most of the county roads were designed and constructed as "farm to market" roads. La Plata County road officials are concerned about rapid deterioration of both roads and bridges in the Study Area from oil and gas traffic (Bennett, personal communication, 1989). Specific issues include the condition of the culvert at the Beaver Creek crossing of LPC 523 and the Sauls Creek Bridge on LPC 527. Additionally, the county has expressed concern over excessive weight limits of posted roads (LPC 523, 502, 505, and 307) and safety

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TABLE 3-26

ROAD ACCESS FOR THE HD MOUNTAINS COALBED METHANE
GAS FIELD DEVELOPMENT EIS STUDY AREA

Road	Location or Segment	ADT[1]	Surface Type	Condition[2]	Bridges	Culverts
<u>Federal</u>						
160	Bayfield to Piedra River	2500	Paved	G	1	N/A
<u>State</u>						
151	Ignacio - Arboles	1350 - 1700	Paved	G	N/A	N/A
<u>Forest Service</u>						
613 (Fosset Gulch Rd.)	US 160 North end	N/A	Gravel	F	0	N/A
123	(C.R.[3] 335)	545	Dirt	F/P	0	N/A
125	C.R. 335 South end	545	Primitive	F/P	0	N/A
126	F.S. 127 North end	545	Primitive	F/P	0	N/A
127	C.R. 523 North end	545	Primitive	F/P	0	N/A
131	C.R. 527 South end	N/A	Dirt	F/P	0	N/A
131A	C.R. 527 South end	N/A	Dirt	F/P	0	N/A
132	U.S. 160 East end	N/A	Primitive	F/P	0	N/A
537	(C.R. 335)	10-25	Gravel	F	0	81
608	(C.R. 527)	20-50	Gravel	F	0	14
608B	C.R. 527 North end	N/A	Dirt	F/P	0	N/A

TABLE 3-26
(Continued)

Road	Location or Segment	ADT[1]	Surface Type	Condition[2]	Bridges	Culverts
608C	C.R. 527 South end	N/A	Dirt	F/P	0	N/A
608C1	F.S. 608C	N/A	Dirt	F/P	0	N/A
610	F.S. 127 West end	N/A	Dirt	F/P	0	N/A
K6101	F.S. 610 North end	N/A	Dirt	F/P	0	N/A
612	F.S. 613 (Fosset Gulch Rd) NE end	N/A	Dirt	F/P	0	N/A
613	(Fosset Gulch Rd) US 160 North end	10-25	Gravel	F	0	N/A
613	(Fosset Gulch Rd) South end	20-50	Gravel	F	2	N/A
615	F.S. 615A South end	N/A	Primitive	F/P	0	N/A
615A	F.S. 613 (Fosset Gulch Rd) South end	N/A	Primitive	F/P	0	N/A
743	U.S. 160	5-15	Gravel	F	0	N/A
755A	F.S. 775 (C.R. 528) East end	N/A	Dirt/Primitive	F/P	0	N/A
756	F.S. 537 South end	N/A	Primitive	F/P	0	N/A
755	(C.R. 528)	N/A	Dirt	F/P	0	N/A
803	U.S. 160 North end	N/A	Dirt	F/P	0	N/A
841	F.S. 613 (Fosset Gulch Rd) North end	N/A	Gravel/Dirt	F/P	0	N/A
841A	F.S. 841 South end	N/A	Dirt	F/P	0	N/A
841B	F.S. 841 North end	N/A	Dirt	F/P	0	N/A
841C	F.S. 841 West end	N/A	Dirt	F/P	0	N/A
841D	F.S. 841C South end	N/A	Dirt	F/P	0	N/A

TABLE 3-26
(Continued)

Road	Location or Segment	ADT[1]	Surface Type	Condition[2]	Bridges	Culverts
841E	F.S. 841 East end	N/A	Dirt	F/P	0	N/A
924	U.S. 160 East end	N/A	Dirt	F/P	0	N/A
La Plata County						
334	C.R. 521 West end	107-172	Gravel	F	3	25
335	C.R. 334 West end	N/A	Gravel	P	0	4
521	Bayfield-Ignacio	628-725	Paved	F/P	0	N/A
522	C.R. 521 West end	81-90	Gravel	F/P	2	6
523	C.R. 521	74-277	Paved/Gravel	F/P	0	14
524	C.R. 521 West end	55	Gravel	F	0	5
525	C.R. 523 West end	88	Gravel	F	0	2
526	US 160	167	Gravel	F/P	0	20
527	C.R. 526 West end	50	Gravel	F/P	1	11
528	C.R. 527 North end	N/A	Gravel/Dirt	P	0	4

N/A - Not Available

[1] Average daily traffic estimates for certain Forest Service roads were provide by USFS.

[2] G = good; F = fair; P = poor

[3] C.R. - County Road

Sources: USFS 1989; La Plata County Roads & Bridges Dept. 1989; Colorado Dept. of Highways 1989; Eberling, 1989, Personal Communication (Archuleta County Dept. of Planning and Roads).

TABLE 3-27

ROAD CONDITION DEFINITIONS FOR
LA PLATA COUNTY

PAVED ROADWAYS

GOOD

1. Pavement is smooth enough to give a "first class" ride.

2. Pavement exhibits few, if any, visible signs of surface deterioration. Asphalt pavements may be beginning to show evidence of rutting and fine random cracks. Concrete pavements may be beginning to show evidence of slight surface deterioration, such as minor cracks and spalling. This random cracking or patching should not be more than 20 percent of the roadway surface being evaluated.

3. Cross-section is uniform, there is positive drainage with good curbs and gutters or ditches.

4. All pavements constructed or resurfaced during the last 12 months would be rated in this category.

FAIR

1. The riding qualities of pavements are noticeably inferior to those of the good category.

2. Asphalt pavement defects may include rutting, map crackling, and patching. Concrete pavements may have a few joint failures, faulting and cracking, and come pumping. This cracking or patching should not be more than 60 percent of the section of roadway surface being evaluated.

3. Cross-section is not uniform, water puddles in areas, curbs and gutters or ditches may be present but drainage is not consistent.

4. Pavements which have been constructed or resurfaced at least 12 months ago and up to 6-9 years ago may fall into this category.

POOR

1. The riding qualities of pavements are noticeably inferior to those of the fair category, and are not tolerable for high speed traffic and may be uncomfortable for medium speed traffic.

2. Asphalt pavement defects may include extensive rutting, map cracking, and extensive patching. Concrete pavements may have several joint failures, faulting and cracking, and major areas of severe pumping. This cracking or patching for a roadway in this category will be greater than 60 percent of the section of roadway surface being evaluated.

3. Cross-section varies, water puddles throughout, curbs and gutters or ditches do not function or do not exist.

TABLE 3-27
(Continued)

4. Pavements have deteriorated to such an extent that they are in need of resurfacing or are in an extremely deteriorated condition that they may need complete reconstruction. Pavements constructed or resurfaced 9-12 years ago may fall into this category.

UNPAVED ROADWAYS*

GOOD

1. Adequate width for safe passage of large vehicles.

2. Graded to a uniform cross-section having a crown and ditches to provide good drainage.

3. Surface is smooth with no washboards, rutting or soft areas, vehicles can safely travel at the posted speed limit.

4. There is adequate gravel uniformly spread across the surface.

5. During periods of wet weather, road will support traffic.

FAIR

1. Adequate width for safe passage of cars and pick-up trucks.

2. Cross-section may vary, crown is not consistent, ditches are not adequate and drainage is not adequate.

3. Surface has occasional washboards and ruts but irregularities do not interfere with safe vehicle operation at the posted speed limit.

4. Gravel is present but lacking in the wheel paths or in short stretches.

5. During periods of wet weather, puddles develop and the road is slippery but will support normal traffic.

POOR

1. Two cars cannot safely pass.

2. Cross-section varies, there is no crown or ditches, water does not drain from the road.

3. Surface has washboards, ruts, and soft areas and vehicles must slow to less than the posted speed limit.

TABLE 3-27
(Continued)

4.	Gravel is sparse or does not exist.
5.	During periods of wet weather, cars cannot safely travel.

* Unpaved roadways are rated on typical conditions through the year and not on worst or best conditions

Source: La Plata County Roads and Bridges Department 1989.

issues regarding narrow road widths (LPC 525 and 528). These issues stem from increased use comparing previous and projected repetitious truck traffic. The FS has expressed concern over the deterioration of Forest roads due to oil and gas traffic. Currently, the Piedra River bridge is deteriorating, with one wingwall of the bridge and two caps undergoing spalling. The Ignacio Creek bridge is also of concern as it is in a deteriorating condition. The FS is also concerned about the deteriorating quality of roads and culverts in the Study Area from increased weights, as well as the safety issues of big trucks and their speed on narrow roads. Section 4.13, Health and Safety, further discusses the traffic safety issues.

3.10 NOISE

Baseline noise levels in the Study Area are expected to range from approximately 35 to 70 decibels (dBA) depending on population density and proximity to existing industrial and agricultural/ranching activities. These noise levels were measured using the A-weighting network. The A-weighting network was designed to simulate human hearing. For example, the human ear does not perceive sounds at low frequencies in the same manner as those at higher frequencies. Sounds at low frequency do not seem as loud as those of equal intensity at higher frequencies. The A-weighting network de-emphasizes lower frequency sounds to simulate the response of the human ear. Since measured noise data do not exist for the Study Area, the range presented has been estimated from empirical techniques and measured data for similar geographic and demographic areas.

The method used to estimate the baseline noise levels in the Study Area is based on a correlation between average population density and average yearly day-night sound levels (L_{DN}), expressed in decibels (dB) (National Academy of Sciences, 1977). The day-night sound level is a logarithmic average of daytime and nighttime sound levels with a 10 dB penalty applied to the nighttime sound levels. This 10 dB penalty is added to the nighttime levels because nighttime sounds can be more irritating than daytime sounds. The relationships between population density and noise levels are presented in Table 3-28. The population of unincorporated La Plata County in 1988 was 16,589 (Colorado Division of Local Governments). The area of unincorporated La Plata county is 1,674 sq. miles (Davidson, personal communication, 1989), resulting in a population density of 10 people per square mile. Based on this population density, ambient noise levels are estimated to range from 35 to 40 dB (Table 3-28), in the absence of any man-made source of noise. Noise levels in more populated or industrialized areas, (e.g., Bayfield and areas where some oil and gas development have already occurred) may be somewhat higher than this range, based upon noise monitoring conducted in support of the Environmental Planning Document Volume 1 for Amoco's San Juan Basin Coal Degas Project (WCC 1988).

TABLE 3-28

TYPICAL VALUES OF YEARLY DAY-NIGHT AVERAGE SOUND LEVELS FOR VARIOUS RESIDENTAL NEIGHBORHOODS WHERE THERE IS NO WELL-DEFINED SOURCE OF NOISE OTHER THAN USUAL TRANSPORTATION NOISE

Description	Population Density (people/sq. mi)	L_{dn} dBa
Rural (undeveloped)	20	35
Rural (partially undeveloped)	60	40
Quiet Suburban	200	45
Normal Suburban	600	50
Urban	2,000	55
Noisy Urban	6,000	60
Very Noisy Urban	20,000	65

L_{dn} = average day-night sound level

Source: NAS 1977.

In this study, average day/night sound levels in downtown Ignacio were found to be approximately 62 dBA. Average day/night sound levels within 500 feet of oil and gas activities (e.g., compressors, pumping units, disposal wells, and drilling operations) were found to range from approximately 50 to 70 dBA. It is reasonable to assume that similar noise levels may be expected in downtown Bayfield and in the immediate vicinity of developed areas in the Study Area. By way of comparison, noise levels below an L_{DN} of 55 dB have been identified as the maximum sound level that will not adversely affect public health and welfare by interfering with outdoor activities (EPA 1974).

3.11 RECREATIONAL RESOURCES

In the Study Area, recreation use or demand is low compared to other areas of the San Juan National Forest. Recreation is generally dispersed. Major activities include hunting, firewood gathering, fishing along the Piedra River, and sightseeing. Camping occurs primarily with hunting.

Recreational resource information was compiled from maps and existing literature provided by public and private agencies. Data sources for the baseline inventory included published information from the Pine District of the San Juan National Forest and the Colorado Department of Parks and Recreation. These agencies also supplied pertinent documents and maps. Other reference materials, including USGS 7.5 minute topographic quadrangle sheets (Scale 1:24,000), BLM surface management quads (Scale 1:1,000,000), and the Colorado Statewide Comprehensive Outdoor Recreation Plan (SCORP), were also examined. The baseline data were supplemented by information provided in meetings and telephone contacts with federal, state, county, and community recreation and land management agencies. Baseline information was collected during summer and fall of 1989.

The following types of recreational resources are described:

- Recreation attractions within the regional setting;
- Developed recreation sites;
- Dispersed recreational activities (including hunting and fishing); and
- Community recreation facilities.

The major regional recreation attraction in the Study Area is seasonal hunting of big game. This is further described under the discussion of dispersed recreational activities. There are no developed recreation sites

within the Study Area. The nearest camp site is the Lower Piedra Campground located 4 miles northeast of the Study Area. Also, the Chimney Rock Archaeological Area, a well known landmark noted for its Indian ruins, is located 3 miles east of the Study Area. Navajo Reservoir State Recreation Area is located approximately 7 miles south of the Study Area. Vallecito Reservoir is 10 miles north, and the Weminuche Wilderness is 20 miles north of the Study Area.

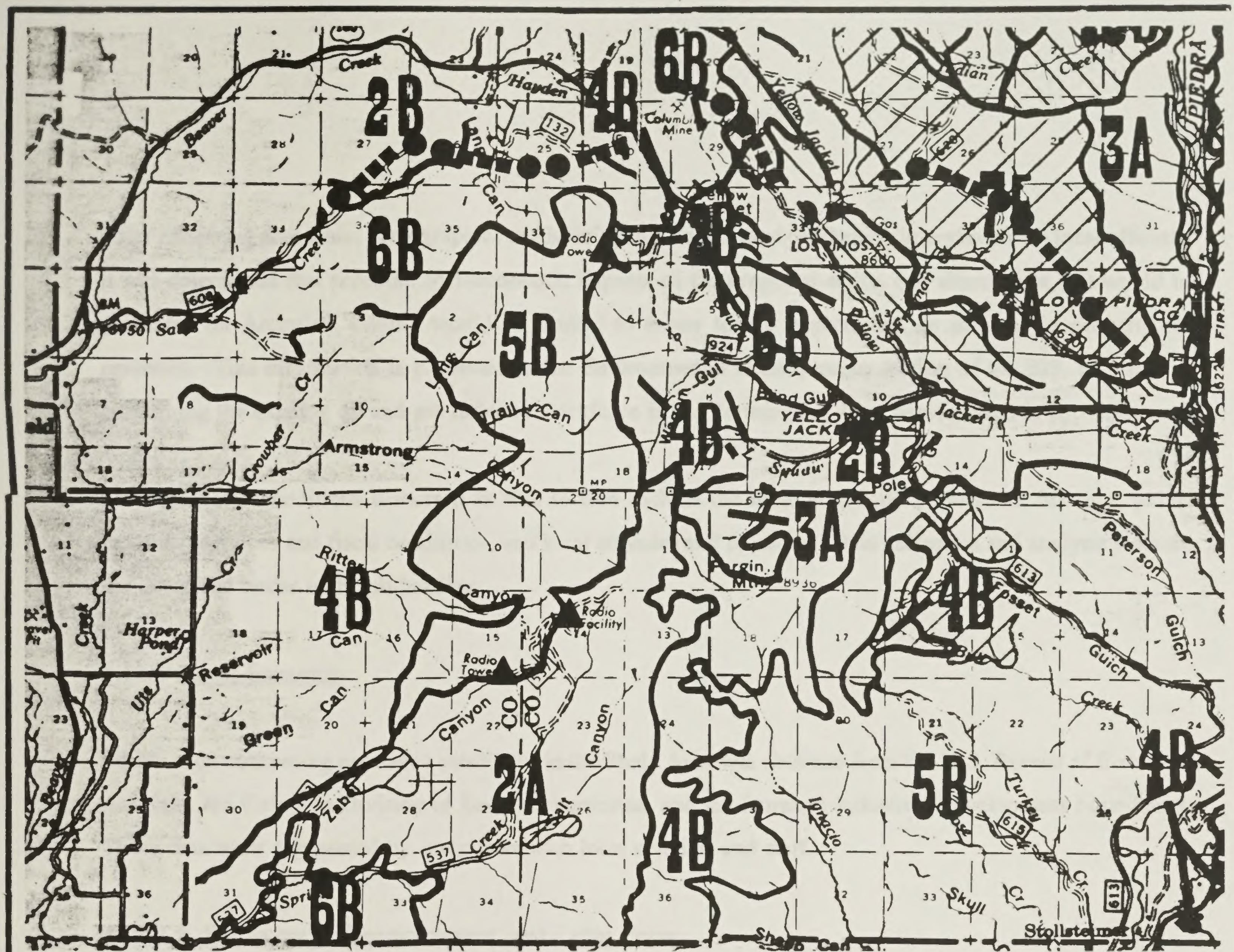
Dispersed recreation represents the most common form of activity in the Study Area. The primary recreational use of the HD Mountains area consists of firewood gathering and elk and deer hunting. For each day during the hunting seasons, an estimated average of 100 visitor days of use occurs. This number is lower during earlier seasons and steadily increases in the late season. Firewood gathering is a popular recreational activity in the HD Mountains. Approximately 1,250 recreational visitor-days were generated in 1989 (Bell, personal communication, 1989). Fishing occurs along the Piedra River, although access to the river is somewhat limited due to private property located between Forest Gulch Road and the river. Sightseeing by vehicle, horseback, and/or foot occurs in portions of the Study Area. Sightseeing is a popular activity along U.S. Highway 160, Spring Creek, Fosset Gulch, and Sauls Creek roads. Winter recreation in the HD Mountains is less popular than in other portions of NFS land. There is minimal All Terrain Vehicle (ATV) and cross-county skiing in the Study Area. Christmas tree harvesting by individuals and families also occurs. The Forest Plan has designated a Management Precipitation Area 3A, located north of Pargin Mountain (see Figure 3-17). The Recreation Opportunity Spectrum is classified with emphasis on semi-primitive, nonmotorized recreation opportunities. Approximately 17,894 acres are unroaded (see Figure 2-1).

There are no community recreation facilities in the Study Area.

3.12 SOCIOECONOMIC CONDITIONS

3.12.1 Introduction

The location of the proposed action and alternatives includes portions of La Plata and Archuleta counties in southern Colorado. The geographic area discussed here is primarily La Plata County with emphasis on the eastern portions of the county, including the communities of Bayfield and Ignacio. Information about Archuleta County is not included in this section. This is because no issues concerning socioeconomic conditions in Archuleta County were identified during the EIS scoping process (Bell, personal communication, 1989.



2A — MANAGEMENT AREA 2A - Emphasizes semi-primitive motorized recreation opportunities such as snowmobiling, four-wheel driving and motorcycling both on and off roads and trails in a naturally appearing environment. Management activities are visually subordinate. Forested lands in portions of the area are not suitable for timber production.

2B — MANAGEMENT AREA 2B - Emphasizes rural and roaded natural recreation opportunities such as driving for pleasure, viewing scenery, and picnicking along sensitive travel routes while enhancing or maintaining scenic qualities inherent in a forest environment. Forested land is suitable for timber production.

3A — MANAGEMENT AREA 3A - Emphasizes semi-primitive non-motorized recreation opportunities. Other resource uses occur if they are compatible with or enhance this type of recreation experience. Forested land is not suitable for timber production; however, wood products are available if harvest is compatible with semi-primitive dispersed recreation. The area is never open for motorized recreation activities except for specifically identified motorized corridors through the area.

4B — MANAGEMENT AREA 4B - Emphasizes wildlife habitat management for one or more indicator species. Roaded natural recreation opportunities will be provided, but vegetation treatment and human activities are managed to provide optimum habitat for the selected species. Forested land is suitable for timber production.

5B — MANAGEMENT AREA 5B - Emphasizes forage and cover on wildlife winter ranges. Livestock grazing is compatible but is managed to favor wildlife habitat. Forested land is suitable for timber production.

6B — MANAGEMENT AREA 6B - Emphasizes livestock grazing through use of intensive grazing management systems and investments in structural and non-structural range improvements. Conflicts between livestock and wildlife are resolved in favor of livestock. Forested lands in portions of the area are not suitable for timber production.

NORTH

1 MILE

SOURCE: FS (1983)

SAN JUAN NATIONAL FOREST MANAGEMENT AREA
MAP FOR THE HD MOUNTAINS STUDY AREA

Figure 3-17

After reviewing economic, demographic, and housing information and conducting interviews with local officials, it was determined that potential socioeconomic impacts of the proposed action and alternatives that would be generated on Archuleta County would be limited to minor traffic impacts and an increase in property tax revenues. This information is presented in the Environmental Consequences section of the EIS. Information concerning the existing oil and gas industry workforce in the Farmington, New Mexico area is also discussed.

Socioeconomic conditions discussed in this section include the local economy, population, housing, public facilities, services and fiscal conditions, and local attitudes and opinions. Data collection and analysis methods are described under each sub-heading.

3.12.2 Local Economy

Information concerning economic conditions in the Study Area was obtained from the U.S. Bureau of Economic Analysis, the Colorado Division of Local Government, and the Durango Industrial Development Foundation. These data were augmented by interviews with local officials and staff.

3.12.2.1 Employment, Unemployment, and Labor Force

Table 3-29 and Figure 3-18 display employment by place of work for La Plata County for the 1980 through 1987 period.

Employment in La Plata County has increased by over 2,000 jobs during the 1980 through 1987 period, at an average rate of 3 percent per year. However, total employment decreased by about 2 percent between 1986 and 1987. Services and Retail Trade are the dominant sectors in the La Plata County economy, averaging 32 percent and 21 percent of total employment, respectively, over the seven-year period. This reflects the importance of the tourism and recreation visitor economy to the county and Durango's position as a trade center. Government employment is the third largest sector in the economy, averaging 15 percent of total employment over the period.

Table 3-30 displays labor force, employment by place of residence, unemployment, and unemployment rate data for La Plata County for the 1980 through 1988 period. Figure 3-19 displays employment and unemployment information for the same period.

TABLE 3-29

EMPLOYMENT BY PLACE OF WORK, 1980-1987
LA PLATA COUNTY, COLORADO

	1980	1981	1982	1983	1984	1985	1986	1987	Average 1980-87
Full and Part Time Jobs									
Farm	828	832	858	882	864	846	857	855	853
Mining	108	144	138	110	115	120	99	92	116
Construction	994	1,105	1,131	1,175	1,454	1,398	1,438	1,414	1,264
Manufacturing	540	574	499	532	631	673	600	557	576
TCPU	576	554	529	555	563	592	610	639	577
Wholesale Trade	363	378	337	346	408	376	343	373	366
Retail Trade	2,876	3,156	3,499	3,621	3,764	3,727	3,691	3,461	3,474
FIRE	1,081	1,123	1,130	1,215	1,320	1,364	1,422	1,346	1,250
Services, inc Ag Svcs	4,217	4,685	4,940	5,046	5,337	5,761	5.872	5,766	5,203
Government	2,432	2,410	2,409	2,456	2,510	2,570	2,602	2,718	2,513
Total Employees	14,015	14,961	15,470	15,938	16,966	17,427	17,534	17,221	16,192
Percent by Sector (Column %)									
Farm	5.9%	5.6%	5.5%	5.5%	5.1%	4.9%	4.9%	5.0%	5.3%
Mining	0.8%	10.%	0.9%	0.7%	0.7%	0.7%	0.6%	0.5%	0.7%
Construction	7.1%	7.4%	7.3%	7.4%	8.6%	8.0%	8.2%	8.2%	7.8%
Manufacturing	3.9%	3.8%	3.2%	3.3%	3.7%	3.9%	304%	3.2%	3.6%
TCPU	4.1%	3.7%	3.4%	3.5%	3.3%	3.4%	3.5%	3.7%	3.6%
Wholesale Trade	2.6%	2.5%	2.2%	2.2%	2.4%	2.2%	2.0%	2.2%	2.3%
Retail Trade	20.5%	21.1%	22.6%	22.7%	22.2%	21.4%	21.1%	20.1%	21.5%
FIRE	7.7%	7.5%	7.3%	7.6%	7.8%	7.8%	8.1%	7.8%	7.7%
Services, inc AG Svs	30.1%	31.3%	31.9%	31.7%	31.5%	33.1%	33.5%	33.5%	32.1%
Government	17.4%	16.1%	15.6%	15.4%	14.8%	14.7%	14.8%	15.8%	15.5%
Total Employees	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Percent Annual Change by Sector									
Farm	NA	0.5%	3.1%	2.8%	-2.0%	-2.1%	1.3%	-0.2%	0.5%
Mining	NA	33.3%	-4.2%	-20.3%	4.5%	4.3%	-17.5%	-7.1%	-2.3%
Construction	NA	11.2%	2.4%	3.9%	23.7%	-3.9%	2.9%	-1.7%	5.2%
Manufacturing	NA	6.3%	-13.1%	6.6%	18.6%	6.7%	-10.8%	-7.2%	0.4%
TCPU	NA	-308%	-405%	4.9%	1.4%	5.2%	3.0%	4.8%	1.5%
Wholesale Trade	NA	4.1%	-10.8%	2.7%	17.9%	-7.8%	-8.8%	8.7%	0.4%
Retail Trade	NA	9.7%	10.9%	3.5%	3.9%	-1.0%	-1.0%	-3.2%	-2.7%
FIRE	NA	3.9%	0.6%	7.5%	8.6%	3.3%	4.3%	-5.3%	3.2%

TABLE 3-29
(Continued)

	1980	1981	1982	1983	1984	1985	1986	1987	Average 1980-87
Services, inc Ag Svcs	NA	0.6%	7.5%	2.1%	5.8%	7.9%	1.9%	-1.8%	4.6%
Government	NA	-0.9%	-0.0%	2.0%	2.2%	2.4%	1.2%	4.5%	1.6%
Total Employment	NA	6.7%	3.4%	3.0%	6.4%	2.7%	0.6%	-1.8%	3.0%

Source: U.S. Bureau of Economic Analysis, Colorado Division of Local Government, Planning Information Corporation, 1989.

TABLE 3-30

LABOR FORCE, EMPLOYMENT BY PLACE OF RESIDENCE AND UNEMPLOYMENT, 1980-1988
LA PLATA COUNTY, COLORADO

1980-88	1980	1981	1982	1983	1984	1985	1986	1987	1988	Average
Residential Workers	14,959	15,651	16,453	16.383	16,856	16,890	16,561	15,601	15,378	16,081
% Chg		4.6%	5.1%	-0.4%	2.9%	0.2%	-1.9%	-5.8%	-1.4%	
Employed	13,736	14,623	14,956	15,046	15,696	15,713	15,113	14,189	14,286	14,818
Unemployed	1,223	1,028	1,497	1,337	1,160	1,177	1,448	1,412	1,092	1,264
% Chg		-15.9%	45.6%	-10.7%	-13.2%	1.5%	23.0%	-2.5%	-22.7%	
Unemployment Rate	8.2%	6.6%	9.1%	8.2%	6.9%	7.0%	8.7%	9.1%	7.1 %	7.9%
% Chg		-19.7%	38.5%	-10.3%	-15.7%	1.3%	25.5%	3.5%	-21.5%	

Source: Colorado Department of Labor and Employment/Colorado Division of Local Government 1989.

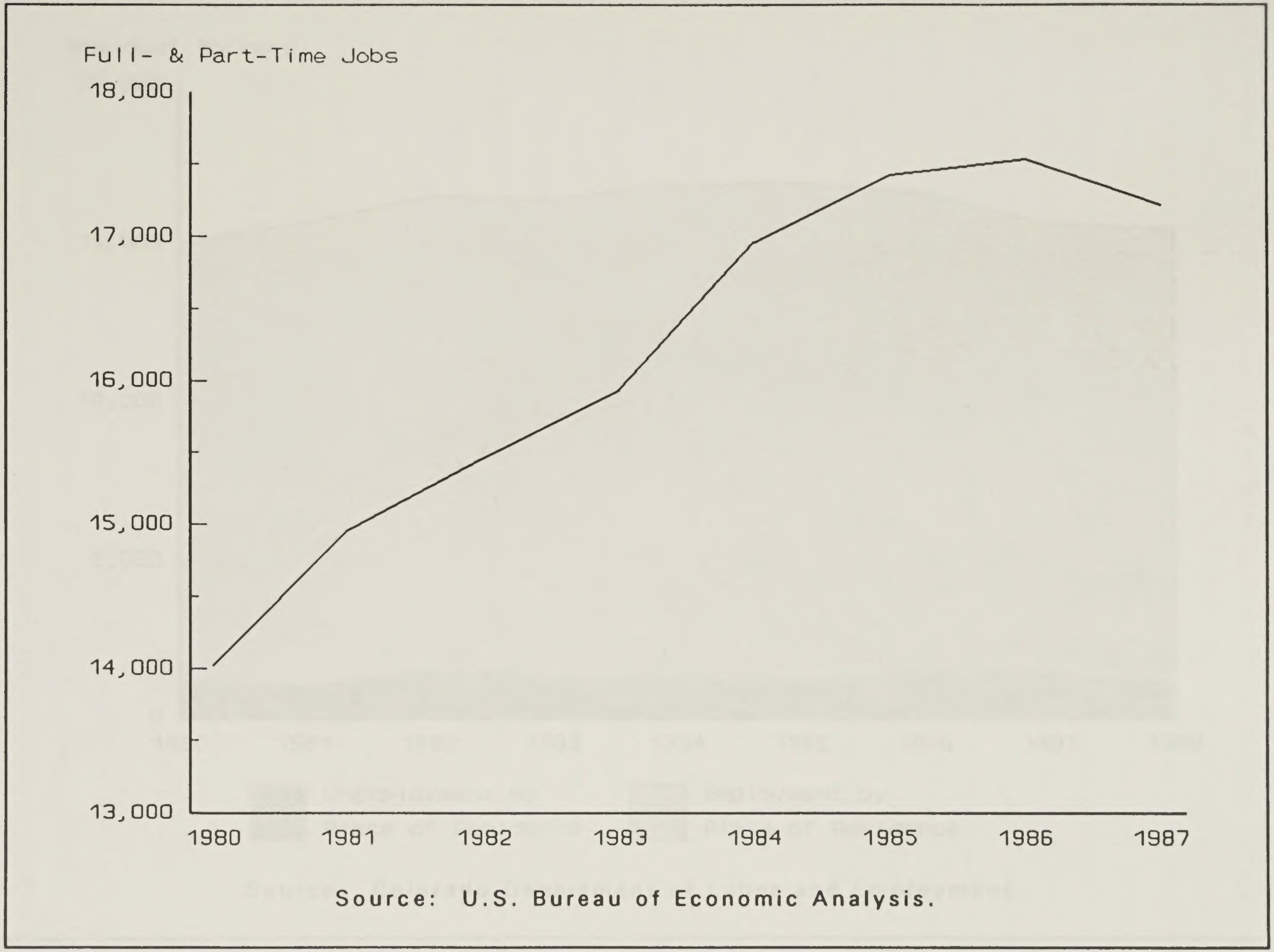


FIGURE 3-18
TOTAL EMPLOYMENT BY PLACE OF WORK
LA PLATA COUNTY, COLORADO

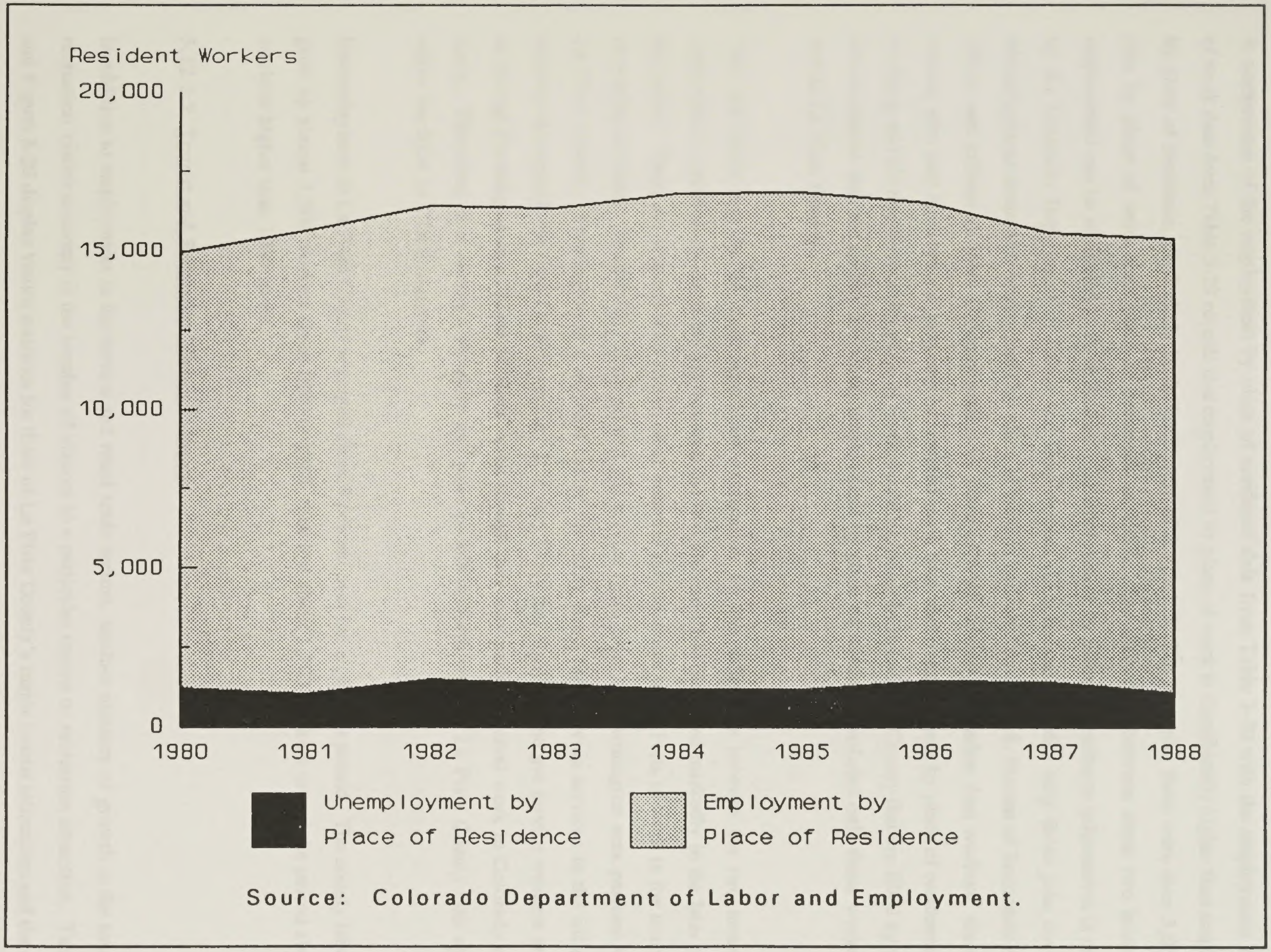


FIGURE 3-19
LABOR FORCE, EMPLOYMENT AND UNEMPLOYMENT
LA PLATA COUNTY, COLORADO

A comparison of the employment by place of residence data from Table 3-30 with the employment by place of work data from Table 3-29 reveals that employment by place of work is significantly higher than employment by place of residence, particularly in the later years of the period. For example, there were over 3,000 more jobs by place of work than place of residence in 1987. The difference between these two measures of employment can be attributed to three factors: (1) employment by place of residence information is compiled by the Colorado Department of Labor and Employment (CDLE) and includes only those jobs covered by unemployment insurance; employment by place of work is collected by the U.S. Bureau of Economic Analysis (BEA) and reflects all jobs; (2) employment by place of work counts jobs rather than workers; therefore, a worker who may have several jobs may be counted more than once; employment by place of residence counts workers; and (3) employment by place of work would include jobs in La Plata County that are filled by workers who commute into the county for work; employment by place of residence includes only those workers who live in La Plata County.

This last factor may be the most significant explanation for the difference between the two measures of employment, particularly since the gap between the two measures has increased markedly in the later years of the period. There are workers who live in other counties that commute to La Plata to work in the tourism and recreation industry. In addition, many oil and gas service firms from the Farmington area perform work in La Plata County. Farmington is a regional center for many firms that provide services to the oil and gas industry throughout the Four Corners region. It is very likely that many oil and gas service workers are listed as having Farmington as a "place of work" even though they may perform actual work in Colorado or other states. Therefore, it is almost a certainty that more people perform work in La Plata County than appear in either the BEA or CDLE statistics.

Unemployment in La Plata County averaged about 8 percent over the eight-year period. The county labor force grew by almost 1,900 workers from 1980 to 1985, then lost about 1,500 workers to end the period about 400 workers higher than 1980 levels.

3.12.2.2 Tourist and Recreation Visitor Industry

In addition to employment in the service and retail trade sectors, another measure of growth in the tourist and recreation visitor economy is the number of visitors to a particular tourist or recreation attraction. Table 3-31 and Figure 3-20 display visitor statistics for three of La Plata County's major tourist attractions and the airport, from the 1978 to 1987 period. These statistics include skier days at the Purgatory Ski Resort, passengers on

TABLE 3-31

DURANGO TOURISM TRENDS, 1978-1987,
LA PLATA COUNTY, COLORADO

Year	Purgatory Ski Resort (Skier Days)	D&SNG Railroad* (Passengers)	Mesa Verde (Visitors)	Airport Passenger (Activity)
1978	258,000	120,000	654,000	102,000
1979	272,000	102,000	474,000**	116,000
1980	177,000	103,000	541,000	99,000
1981	251,000	124,000	590,000	90,000
1982	279,000	143,000	603,000	88,000
1983	278,000	147,000	604,000	107,000
1984	306,000	170,000	517,000	159,000
1985	306,000	171,000	656,000	178,000
1986	330,000	173,000	659,000	191,000
1987	338,000	172,000***	729,000	195,000

* The railroad ran a winter train in 1981 through 1985.

** Mesa Verde Park was closed in May 1979, due to road construction.

*** The railroad ran only 6 months (May - October)

Source: From the respective operations.
"Tourism-Focus on Business" - Durango Herald, February 21, 1988.

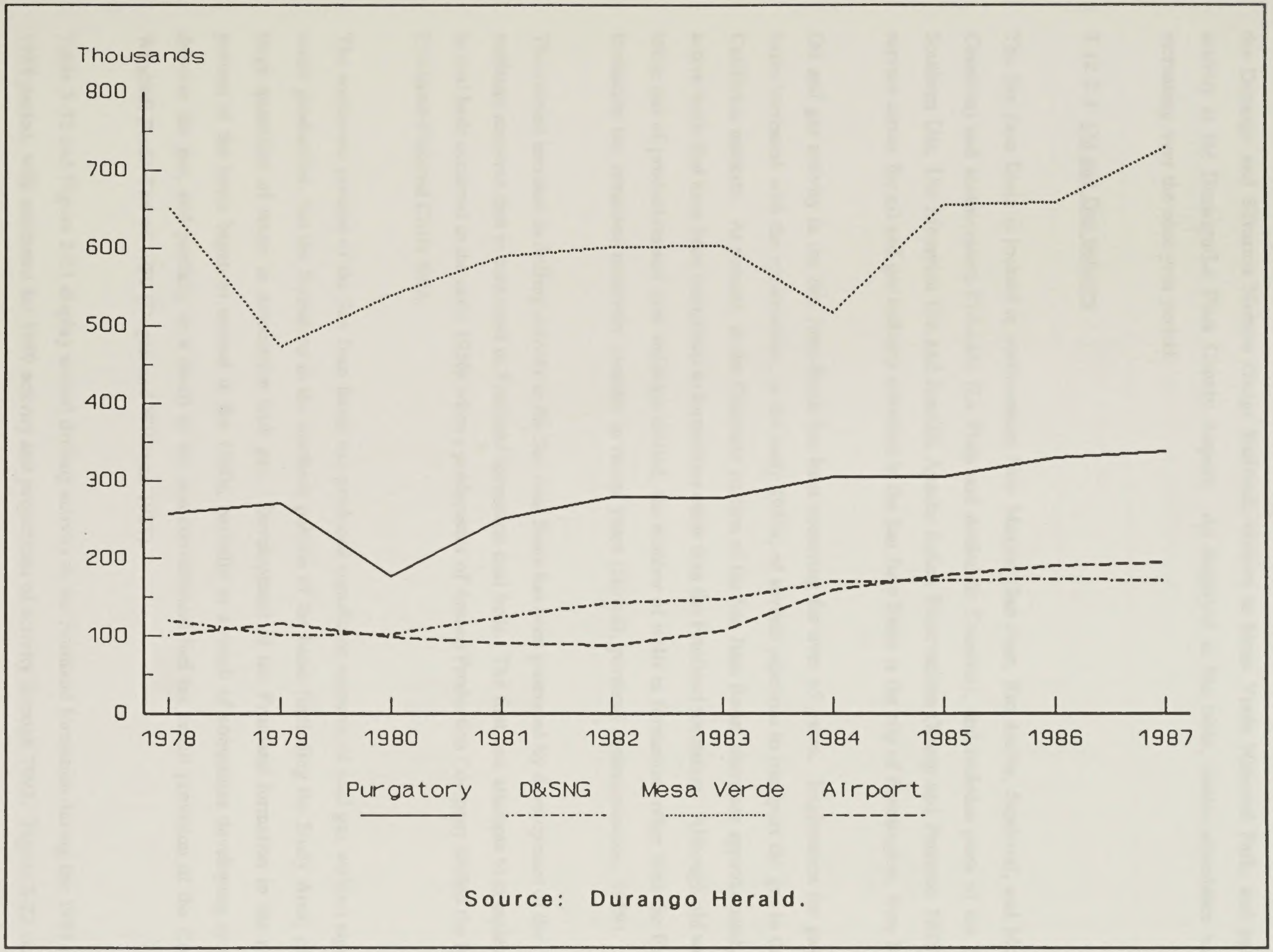


FIGURE 3-20
DURANGO TOURISM TRENDS, 1978-1987
LA PLATA COUNTY COLORADO

the Durango and Silverton Narrow Gauge Railroad, visitors to Mesa Verde National Park, and passenger activity at the Durango/La Plata County Airport. As displayed in the table, visitor attendance has been increasing over the nine-year period.

3.12.2.3 Oil and Gas Industry

The San Juan Basin is located in northwestern New Mexico (San Juan, Rio Arriba, Sandoval, and McKinley Counties) and southwestern Colorado (La Plata and Archuleta Counties), and includes parts of the Navajo, Southern Ute, Ute Mountain Ute and Jicarilla Apache Indian Reservations (Kemp and Peterson 1988). The service center for oil and gas industry activities in the San Juan Basin is the city of Farmington, New Mexico.

Oil and gas activity in the San Juan Basin has been occurring for over 65 years. Exploration for gas in the basin increased with the construction, in the early 1950s, of several pipelines to transport the gas to the large California markets. At present, in the Colorado portion of the San Juan Basin, there are approximately 1,000 active wells that have been completed to formations other than the Fruitland formation. Although old wells are taken out of production and new wells are drilled, the number of wells in formations other than the Fruitland formation has remained relatively constant in recent years (Stowell, personal communication, 1989).

The current increase in drilling activity in the San Juan Basin has been generated by development of the coalbed methane resource that is contained in Fruitland formation coal beds. The first true attempts to complete wells in coal beds occurred in the early 1950s when a predecessor of Amoco Production Company drilled the Ignacio-Fruitland-Pictured Cliffs field.

The southwest portion of the San Juan Basin has produced significant amounts of coal gas without significant water production, but the formation in the northern portion of the basin (including the Study Area) produces large quantities of water in association with gas. Development of the Fruitland formation in the northern portion of the basin began in earnest in the 1980s, partially as a result of companies developing systems to dewater the gas, and partially as a result of the non-conventional fuel tax credit provision of the Crude Oil Windfall Profit Tax of 1980 (Dugan and Williams 1988).

Table 3-32 and Figure 3-21 display annual drilling activity in the Fruitland formation during the 1983 through 1988 period, with estimates for 1989 activity and projections of activity through 1993. Figure 3-22 contrasts

TABLE 3-32

COALBED METHANE DRILLING ACTIVITY: HISTORIC AND PROJECTED
LA PLATA COUNTY, COLORADO

Year	Actual Wells	Projected Wells 3-Yr Schedule	Project Wells 4-Yr Schedule
1983	9		
1984	13		
1985	35		
1986	8		
1987	39		
1988	243		
1989	200 (est.)		
1990		235	175
1991		235	175
1992		235	175
1993			175

Source: COGCC 1989.

Source: Colorado Oil & Gas Conservation Commission.

FIGURE 3-21
COALBED METHANE DRILLING ACTIVITY: HISTORIC AND PROJECTED
LA PLATA COUNTY, COLORADO

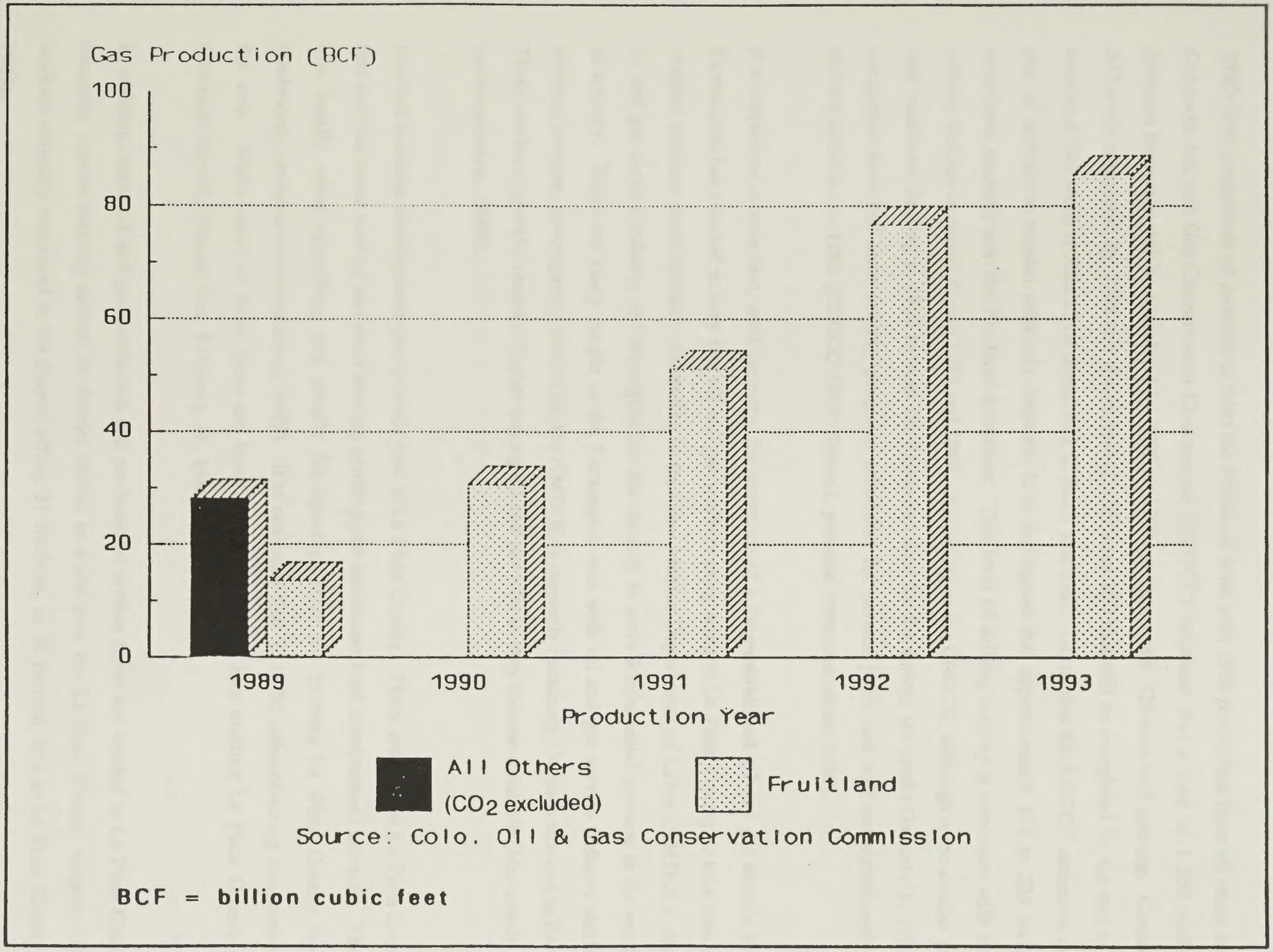


FIGURE 3-22
PROJECTED LA PLATA COUNTY COALBED METHANE PRODUCTION FROM FRUITLAND ZONE CONTRASTED TO 1989 PRODUCTION FROM ALL OTHER ZONES

1989-1993 projections of production from the Fruitland zone with 1989 production from all other zones. The Colorado Oil and Gas Conservation Commission (COGCC) estimates that a total of 1,250 wells into the fruitland formation will be completed by 1992 or 1993, at the current 320-acre well spacing. Considering the 347 wells completed by 1988 and the estimated additional 200 that will be completed by the end of 1989, an estimated 703 wells remain to be completed to reach this total. Given that the COGCC estimates the current rate of activity to remain relatively constant, it is anticipated that approximately 175 to 235 wells will be completed annually into the Fruitland formation. This level of drilling activity is consistent with the level of activity that has occurred during 1988 and 1989. According to the COGCC, although some smaller companies may accelerate drilling in 1990 to meet the expiration date for the energy tax credit (January 1, 1991), larger companies have had their drilling programs scheduled for several years and will not significantly increase drilling activities in 1990 (COGCC 1989; Stowell, personal communication, 1989).

It is important to note that, until recently, the existence of a long-established oil and gas service industry in Farmington has resulted in very few oil and gas workers emigrating to La Plata County to take jobs related to coalbed methane development. According to the New Mexico Department of Labor (NMDOL), the existing oil and gas service industry in Farmington has the capacity to serve a substantial increase in the existing level of activity. There are many people in the Farmington area with oil and gas service industry skills that are working in other, lower-paying industries; the NMDOL is currently retraining 150 such workers in Farmington. These workers typically return to higher-paying oil and gas jobs as they become available (McAninch, personal communication, 1989).

Coalbed methane development does provide jobs in La Plata County. There are several La Plata County firms that provide water hauling and earth moving (drilling pad and access road construction) services. These firms hire locally when expanding, and usually fill openings from the existing La Plata County labor force (Dobrovny, personal communication, 1989). It is estimated that 30 to 50 subcontracting companies work in the area. While many of these firms are from out-of-state, some hire existing La Plata County residents (Durango Herald, Natural Gas, February 19, 1989).

In addition, some oil and gas production and professional service firms are located in La Plata County. For example, Amoco recently moved its district offices to a site near the La Plata County Airport. Of the 36 workers currently employed in the district office, 31 workers, or 86 percent, live in La Plata County (Amoco 1989).

Until recently, infrastructure development has been keeping pace with drilling, and the development of roads, flowlines, and produced water disposal facilities has remained relatively constant. However, the development of pipelines and compression facilities has increased during late 1989 and 1990. At present, Amoco has received county permits to construct a compression/water disposal facility near Bayfield and a compression facility on Florida Mesa. Construction of these facilities began in the third quarter of 1989 and should be completed by November of 1990 (Amoco 1989). In September of 1989 there were over 200 construction employees working on these projects, with approximately 50 percent drawn from the local workforce (Pine River Times, October 12, 1989). Peak employment associated with these facilities could be as high as 500 workers (Amoco 1989). Several other companies have announced intentions to seek permits for compression facilities. The workforce and schedules associated with these projects is not currently known (Bonser, personal communication, 1989).

3.12.2.4 Economic Effects

The economic effects of coalbed methane development in La Plata County include both direct and indirect effects. Public sector tax revenue effects are discussed in a subsequent section.

The direct economic effects of coalbed methane development include the following:

- Purchases of materials, supplies, equipment, and services from La Plata County vendors;

- Payments to La Plata County property owners for surface leases and royalties for subsurface mineral rights;

- Salaries and wages paid to employees of oil and gas exploration, production, and service companies;

Indirect economic effects include:

- Purchases of goods, services, and rentals made by employees of coalbed methane exploration, production, and service companies who reside in La Plata County; and

- Purchases of goods and services made by employees of coalbed methane production and service companies who reside outside La Plata County while they are working in the county.

Although, to our knowledge, no analysis quantifying the economic effects of coalbed methane development has been performed for La Plata County, it is reasonable, given the magnitude of ongoing activities, to assume that the oil and gas development has significantly increased total wages, salaries, and income in the county.

Various individuals and citizens' groups have expressed concerns about potential negative effects of coalbed methane development on other components of the La Plata County economy, such as tourism, recreation, and vacation and retirement home development. To our knowledge, no data concerning such effects currently exist. At the time of this assessment (October 1989), the effects of coalbed methane development have not been an expressed concern of the members of the Durango Area Chamber and Resort Owners Association (Dexter, personal communication, 1989). La Plata County commissioned a study to assess these potential effects (Bonser, personal communication, 1990); a draft of this study is currently available from La Plate County.

3.12.2.5 Summary

Employment in La Plata County increased steadily between 1980 and 1986, then decreased slightly in 1987 and 1988. Although 1989 statistics have not been compiled at the time of this analysis, preliminary indications are that the tourism and recreation economy have strengthened in La Plata County and employment has increased (Durango Herald, June 15, 1989).

Employment associated with the coalbed methane resource is increasing; however, many of the drilling and well development jobs are performed by employees of service companies based in Farmington. Some operations workers appear to be locating in La Plata County (Amoco 1988; McGill, personal communication, 1989).

3.12.3 Population

Population estimates were obtained from the U.S. Bureau of Census and the Colorado Division of Local Government. Table 3-33 displays 1980 through 1988 population estimates, growth rates, and population shares

TABLE 3-33

POPULATION: APRIL 1980, JULY 1980-1988
LA PLATA COUNTY, COLORADO

	1980 April	1981 July	1982 July	1983 July	1984 July	1985 July	1986 July	1987 July	1988% July	Change % 1980-88	Ave Ann Change 1980-88
County and Municipal Population											
La Plata County	27,195	28,405	29,409	30,512	30,638	30,852	30,163	30,234	30,373	11.7%	1.4%
Bayfield	724	761	795	847	875	892	869	868	870	20.2%	2.3%
Durango	11,649	12,069	12,416	12,733	12,680	12,677	12,267	12,228	12,237	5.0%	0.6%
Ignacio	667	699	730	735	719	717	687	677	677	1.5%	0.2%
Unincorporated	14,155	14,876	15,558	16,197	16,364	16,566	16,340	16,461	16,589	17.2%	2.0%
County and Municipal Population Shares											
La Plata County	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%		
Bayfield	2.7%	2.7%	2.7%	2.8%	2.9%	2.9%	2.9%	2.9%	2.9%		
Durango	4Q.8%	42.5%	42.1%	41.7%	41.4%	41.1%	40.7%	40.4%	40.3%		
Ignacio	2.5%	2.5%	2.5%	2.4%	2.3%	2.3%	2.3%	2.2%	2.2%		
Unincorporated	52.1%	52.4%	52.7%	53.1%	53.4%	53.7%	54.2%	54.4%	54.6%		
Change in County Population with Components of Change											
La Plata County	27,195	28,405	29,499	30,512	30,638	30,852	30,163	30,234	30,373		
Net Change		1,210	1,094	1,013	126	214	(689)	71	139		
% Chg		4.4%	3.9%	3.4%	0.4%	0.7%	-2.2%	0.2%	0.5%		
Births		588	496	545	548	549	505	473	475		
Deaths		256	194	195	190	181	193	198	192		
Net Natural Increase			332	302	350	359	368	312	275	283	
Net Migration		878	793	664	(233)	(154)	(1,001)	(204)	(144)		

Note: Total population includes persons residing in group quarters.

Source: County and Municipal Population -- April 1980, Bureau of the Census/Colorado Division of Local Government; July 1980-88, Colorado Division of Local Government; Births and Deaths -- Colorado Department of Health/Colorado Division of Local Government; Planning Information Corporation.

for La Plata County and its municipalities, and components of population change for the county as a whole. Figure 3-23 graphically displays county and municipal population change for the same period. Figure 3-24 displays the components of population change. La Plata County population has increased from the 1980 census count of 27,195 to an estimated 30,373 in 1988, an increase of almost 12 percent for an average of 1.4 percent annually. However, there was a sharp decline in 1986, and 1988 population was lower than the 1985 peak of 30,852.

In 1988 almost 55 percent (16,589) of La Plata County residents lived in unincorporated portions of the county. About 40 percent (12,237) of the population lived in Durango, 3 percent (870) in Bayfield, and 2 percent (677) in Ignacio. Over the eight-year period, the unincorporated area has grown the greatest amount, both in absolute numbers and in share of the total county population.

Between 1984 and 1988, all growth in the county was attributable to net natural increase (the number of births minus the number of deaths occurring in the county). Net migration (the number of people moving into the county contrasted with the number of people moving out of the county) was negative during those years. In 1986, net migration was a negative 1,000 and net natural increase was a positive 300, for a net population loss of about 800 persons. Population statistics are not yet available for 1989; however, preliminary indications are that La Plata County population is growing as a result of people moving into the area (Brengle, personal communication, 1989; Lee, personal communication, 1989).

Table 3-34 presents projections of the total La Plata County population for the 1989-1995 period. These projections are based on a cohort survival component which considers death and birth rates, and a net migration component which assumes an average annual migration rate. Consequently, significant changes in net migration (such as those caused by significant growth or decline in a specific industry) would result in changes in the projections.

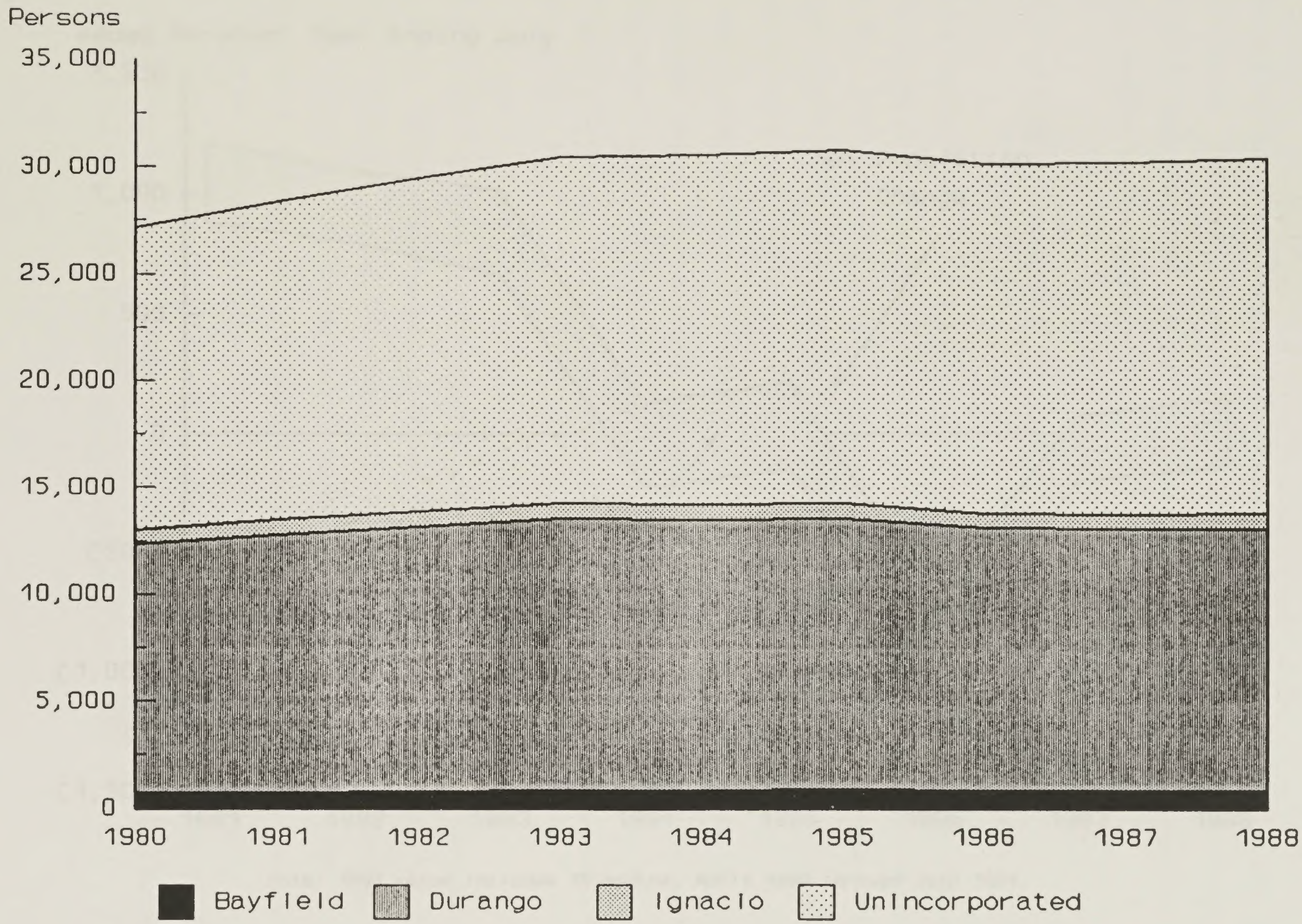
The projections indicate that La Plata County population is anticipated to grow from the 1989 level of 30,846 to a 1995 level of 33,888, an increase of 3,042 or 10 percent over the six-year period, which is an average annual rate of 2 percent.

TABLE 3-34

POPULATION PROJECTIONS: 1989-1995
LA PLATA COUNTY, COLORADO

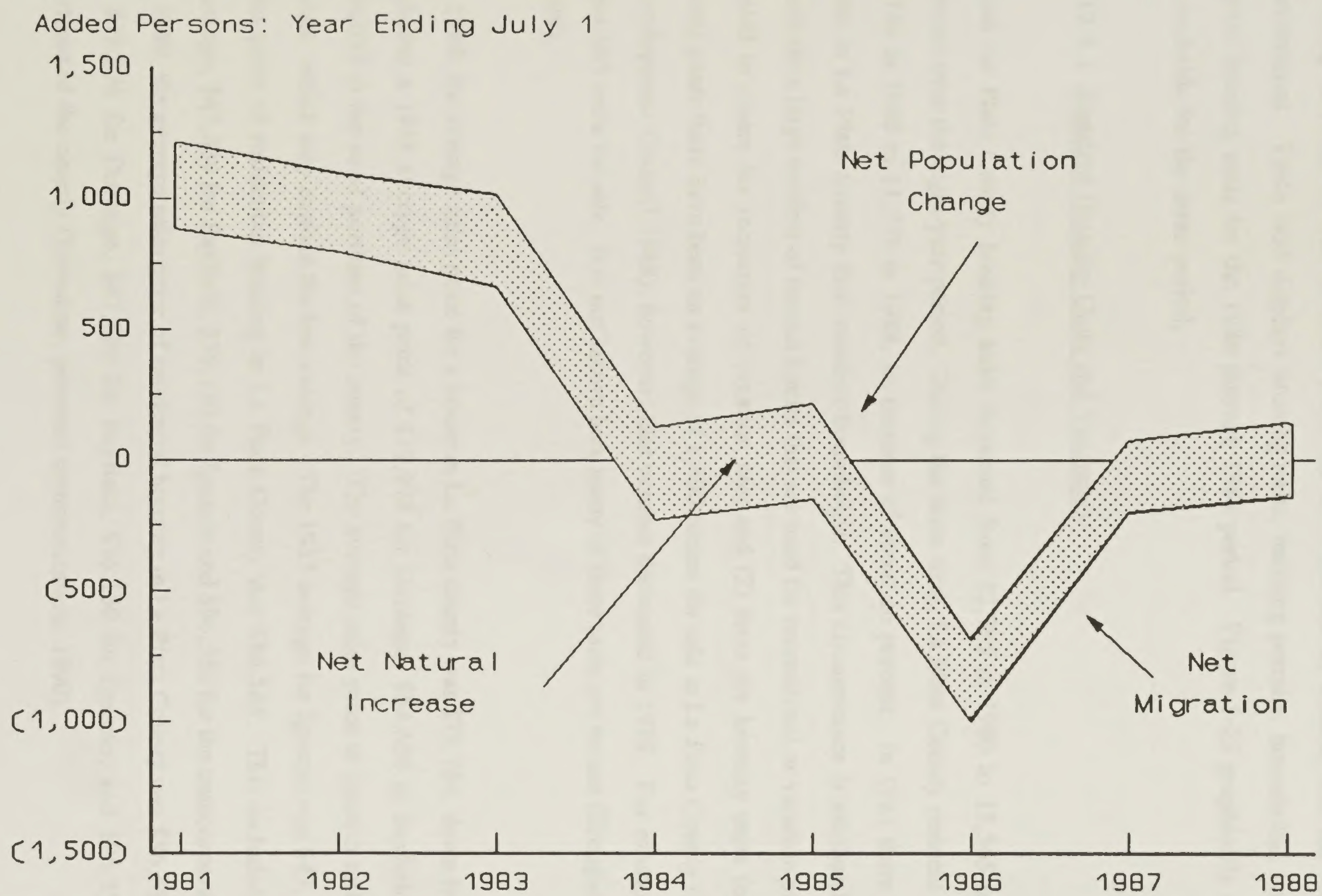
Total County	1989	1990	1991	1992	1993	1994	1995	% Change 1980-88	% Avg. Annual Change 1980-88
	30,846	31,359	31,871	32,279	32,884	33,387	33,888	11.7	1.4

Source: Colorado Division of Local Government 1989.



Source: Colorado Division of Local Government.

FIGURE 3-23
COUNTY AND MUNICIPAL POPULATION
LA PLATA COUNTY, COLORADO



Note: 1981 value includes 15 months, April 1980 through July 1981.

Source: Colorado Division of Local Government.

FIGURE 3-24
COMPONENTS OF COUNTY POPULATION CHANGE
LA PLATA COUNTY, COLORADO

3.12.4 Housing

Housing information was obtained from the U.S. Bureau of Census and the Colorado Division of Local Government. Table 3-35 displays housing units, building permits, households, and vacation, recreation and vacant housing units for the 1980 through 1988 period. Figure 3-25 graphically displays housing units and households for the same period.

3.12.4.1 Standard Housing Units and Vacancies

Total La Plata County housing units increased from 12,765 in 1980 to 15,565 in 1988, an increase of 28 percent over the eight-year period. During the same time, La Plata County resident households increased from 9,746 in 1980 to 11,279 in 1988, an increase of about 16 percent. In 1988 there were 4,286 more housing units in La Plata County than resident households. This circumstance is attributable to several factors: (1) there are a large number of second homes that are used for recreational or vacation purposes, or, in some cases, rented to others for recreation or vacation use; and (2) there are housing units for sale that are vacant. In recent years there have been an average of 1,500 homes for sale in La Plata County (La Plata County Economic Development Council 1988); however, that number decreased in 1989. For example, on November 20 there were 693 units for sale. It is not known how many of these units are vacant (Brengle, personal communication, 1989).

In 1988, the average sales price for a house in La Plata county was $79,784, down from $83,264 in 1987. This included a 1988 average sales price of $79,978 for Durango, $54,650 in Bayfield, $29,700 in Ignacio and $84,058 in the rural portions of the county. The average sales price in Ignacio reflects the sales of only four homes, which may explain the low average. The 1987 average for Ignacio was $47,700. In 1989, the average sales price of residential housing in La Plata County was $86,583. This included averages for $79,876 for Durango, $47,839 for Bayfield, $36,130 for Ignacio and $96,350 for the unincorporated portions of the county. In 1989, the average sales price of residential housing in La Plata County was $86,583. This included averages of $79,876 for Durango, $47,839 for Bayfield, $36,130 for Ignacio, and $96,350 for the unincorporated portions of the county (Ernestine, personal communication, 1990).

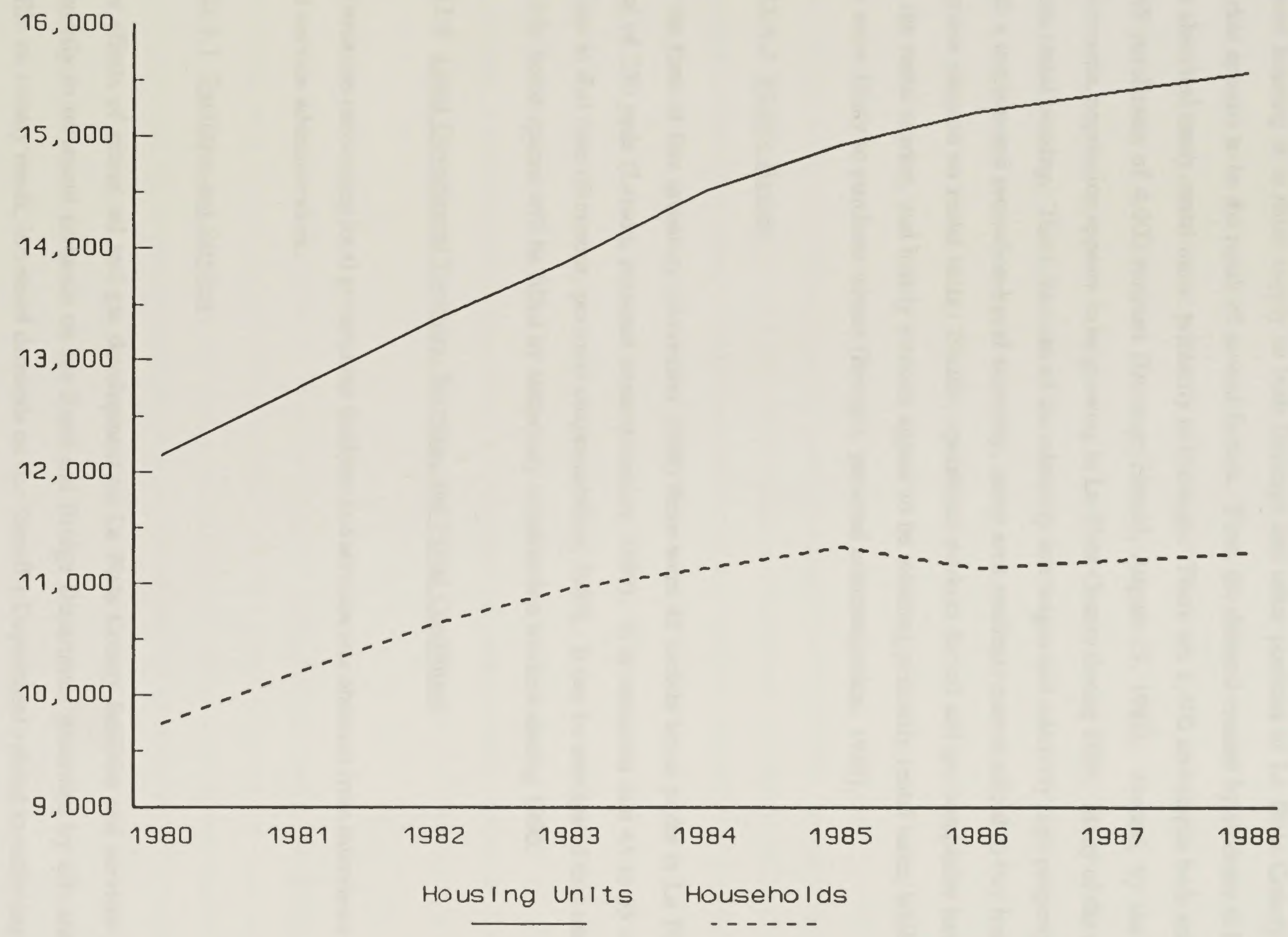
TABLE 3-35

HOUSING, HOUSEHOLDS, BUILDING PERMITS AND VACANT HOUSING, 1980-1988
LA PLATA COUNTY, COLORADO

	1980	1981	1982	1983	1984	1985	1986	1987	1988	% Change 1980-88	Avg Ann % Change 1980-88
Housing Units	12,154	12,765	13,373	13,904	14,523	14,935	15,223	15,400	15,565	28.1%	3.1%
% Chg	5.0%	4.8%	4.0%	4.5%	2.8%	1.9%	1.2%	1.1%			
Building Permits	302	299	293	382	429	304	194	139	NA		
% Chg	-1.0%	-2.0%	30.4%	12.3%	-29.1%	-36.2%	-28.4%				
Resident Households	9,746	10,211	10,643	10,967	11,138	11,329	11,137	11,213	11,279	15.7%	1.8%
% Chg	4.8%	4.2%	3.0%	1.6%	1.7%	-1.7%	0.7%	0.6%			
Vacation/Recreation/ Vacant Units	2,408	2,554	2,730	2,937	3,385	3,606	4,086	4,187	4,286	78.0%	7.5%
% Chg	6.1%	6.9%	7.6%	15.3%	6.5%	13.3%	2.5%	2.4%			

Note: Building permits include both private and public new housing units minus demolitions, but exclude mobile homes and trailers.

Source: U.S. Bureau of the Census/Colorado Division of Local Governments 1989.



Source: Colorado Division of Local Government.

FIGURE 3-25
HOUSING UNITS AND HOUSEHOLDS
LA PLATA COUNTY, COLORADO

3.12.4.2 Rental Housing

Rental housing is in short supply in both Durango and other portions of La Plata County. The tight rental market appears to be the result of several factors. First, the demand created by students at Fort Lewis College has absorbed many rental units, primarily in Durango. There are 1,400 on-campus beds and an estimated fall 1989 enrollment of 4,000 students (Durango Herald, August 13, 1989). Second, by the accounts of many informants, population appears to be growing in La Plata County during 1989. Many of the new residents have taken rental housing. Third, because of the relatively low wages and relatively high property values associated with a tourism-and recreation-based economy, many area residents cannot afford to buy homes, and therefore increase demand on rental units. Finally, operations workers for oil and gas companies have had some effect on the rental market, and hourly workers appear to be selecting primarily rental units, while salaried workers are more likely to purchase homes (Brengle, personal communication, 1989).

3.12.4.3 Mobile Homes

At the time of this inventory (November 1989) there were 42 mobile home parks in La Plata County with a total of 230 pads (Larson, personal communication, 1989). It is estimated that 45 to 55 of these pads were vacant at that time (Simmons, personal communication, 1989). It can be anticipated that many of these vacant mobile home spaces will be filled by temporary construction workers during 1990.

3.12.5 Local Government Facilities, Services, and Fiscal Conditions

Information concerning local government facilities and services was obtained from interviews with local officials and service administrators.

3.12.5.1 Facilities and Services

The effects of recent oil and gas development on La Plata County facilities and services have been limited primarily to increased demands on the Road and Bridge Department generated by oil- and gas-related truck traffic on county roads, increased demands on the Sheriff's Department related to enforcing traffic ordinances on trucks serving oil and gas operations, and increased demands on general government (County Commissioners, Planning and Zoning Commission, Planning Department, Attorney, etc.) related to developing

oil and gas development regulations, handling applications, and dealing with issues relative to oil and gas development.

As noted earlier, the activities associated with the development of the coalbed methane resource have been primarily performed by oil and gas service firms based in Farmington, New Mexico. Historically, there have been few workers moving into La Plata County to obtain employment in that industry. Consequently, the relatively few workers who have moved into La Plata County to work in the coalbed methane industry have not strained public facilities and services in La Plata County, the towns of Bayfield and Ignacio, or the Bayfield and Ignacio School Districts (Bonser, personal communication, 1989; Joswick, personal communication, 1989; Lee, personal communication, 1989; Schelhaas, personal communication, 1989; Fauble, personal communication, 1989).

This circumstance is changing. La Plata County has issued permits for the development of two major oil and gas facilities and has had indications that applications may be submitted for as many as five more major facilities. These facilities will require a temporary construction workforce. It is not yet known how much of this workforce would be drawn from La Plata County and Farmington and how much would be drawn from other areas. In October of 1989, three companies had a total of about 200 workers involved in the construction of pipelines and construction facilities. An estimated half of these workers were local (Pine River Times, October 12, 1989). Workers from other areas will generate demands for temporary housing (motels, hotels, mobile home parks, recreation vehicle parks, and campgrounds). Temporary workers will generate some demands on local government facilities and services in communities where temporary housing facilities are located.

3.12.5.2 Local Government Fiscal Conditions

Oil and gas development contributes to county, school district, and special district revenues primarily through the ad valorem property tax on produced oil and gas and oil and gas field equipment. La Plata County also receives sales tax revenues on purchases made within the county. However, since La Plata County (except for the City of Durango) does not have a local use tax, the county receives no tax revenues on purchases made outside the county.

The La Plata County assessed valuation attributable to oil and gas properties was approximately $54 million in 1989, which was a 22 percent increase over the 1988 level of $44 million. The La Plata County assessed

valuation will increase dramatically as additional coalbed methane wells are drilled and dewatered. As an example, Figure 3-26 displays the property tax revenues that would accrue to La Plata County based on the COGCC production estimates presented in Figure 3-22, assuming a $1.25 per thousand cubic feet (mcf) sales price inflated 5 percent annually and a constant 1990 mill levy. Using these assumptions, property tax revenues to La Plata County generated by coalbed methane would increase from a 1989 level of just under $200,000 to a 1993 level of almost $1,000,000.

Counties and municipalities in Colorado that are experiencing socioeconomic impacts from mineral or energy development are eligible for distributions from the local government severance tax fund. Distributions in La Plata County are made according to the percentage of oil and gas industry workers living in the municipalities or unincorporated portions of the county. La Plata County and its incorporated communities also receive a portion of the severance tax revenues paid by oil and gas companies to the state. In 1989, La Plata County received $11,731 in severance tax revenues, down from $25,000 in 1988. However, all La Plata County municipalities received substantial increases in severance tax revenues in 1989. Durango received $47,017, compared to $12,079 the previous year. Bayfield received $56,366, compared to $6,247 in 1988, and Ignacio received $44,003, compared to $11,662 (Durango Herald, September 30, 1989).

Table 3-36 displays a summary of the 1990 La Plata County, Bayfield and Ignacio school district budgeted revenues. These jurisdictions would receive property tax revenues from the proposed action and alternatives. In addition, Archuleta County and Archuleta School Districts 10-JT and 50 would receive property tax revenues.

In 1989, about 11 percent of La Plata County's total assessed valuation was attributable to oil and gas development (Colorado Division of Property Taxation 1989). This percentage is expected to increase dramatically once recently drilled coalbed methane wells begin producing and are dewatered.

3.12.6 Attitudes, Opinions, and Lifestyles

This section describes attitudes and opinions about current and historic oil and gas activities in La Plata County and attempts to identify how those activities have affected lifestyles within the Study Area or how those lifestyles may be affected in the future. Information for this section was obtained by reviewing EIS scoping documents and meeting notes, interviewing certain local officials and residents, and reviewing newspaper articles concerning oil, gas, and other natural resource development.

lifestyles will continue to [illegible] additional coalbed methane wells are drilled and developed. As an example, Figure 3-26 displays the property tax revenues that would accrue to La Plata County based on the COGCC production estimates presented in Figure 3-22, assuming a $1.25 per thousand cubic feet (mcf) sales price inflated 4 percent annually and [illegible] between 1990 and 1993. Using these assumptions, property tax revenues to La Plata County generated by methane would increase from a 1990 level of just under $400,000 to a 1993 level of almost $1,000,000.

Counties and municipalities in Colorado that are experiencing [illegible] revenue from increases in energy development are eligible for [illegible] the fund. The allocation of La Plata County's [illegible] according to the percentage of oil and gas industry workers living in the municipalities or unincorporated portions of the county. La Plata County and its incorporated communities also receive a portion of the severance tax revenues paid by oil and gas companies to the state. In 1989, La Plata County received $11,724 in severance tax revenues, down from $29,000 in 1988. Similarly, all La Plata County municipalities [illegible] severance tax revenues in 1989. Durango received $47,070, compared to $52,079 the previous year; Bayfield received $10,438, compared to $10,047 in 1988, and Ignacio received $14,992, compared to $16,643 (Durango Herald, September 1989).

Table 3-38 displays the summary of the 1989 La Plata County tax levies and Ignacio School District mill levies. These [illegible] would [illegible] property tax revenues from the proposed actions and alternatives. In addition, Archuleta County and Archuleta School District 50 JT and [illegible] would receive property tax revenues.

In 1989, about 11 percent of La Plata County's total assessed valuation was attributable to oil and gas development (Colorado Division of Property Taxation 1989). This percentage is expected to increase dramatically once recently drilled coalbed methane wells begin producing and are dewatered.

3.12.6 Attitudes, Opinions, and Lifestyles

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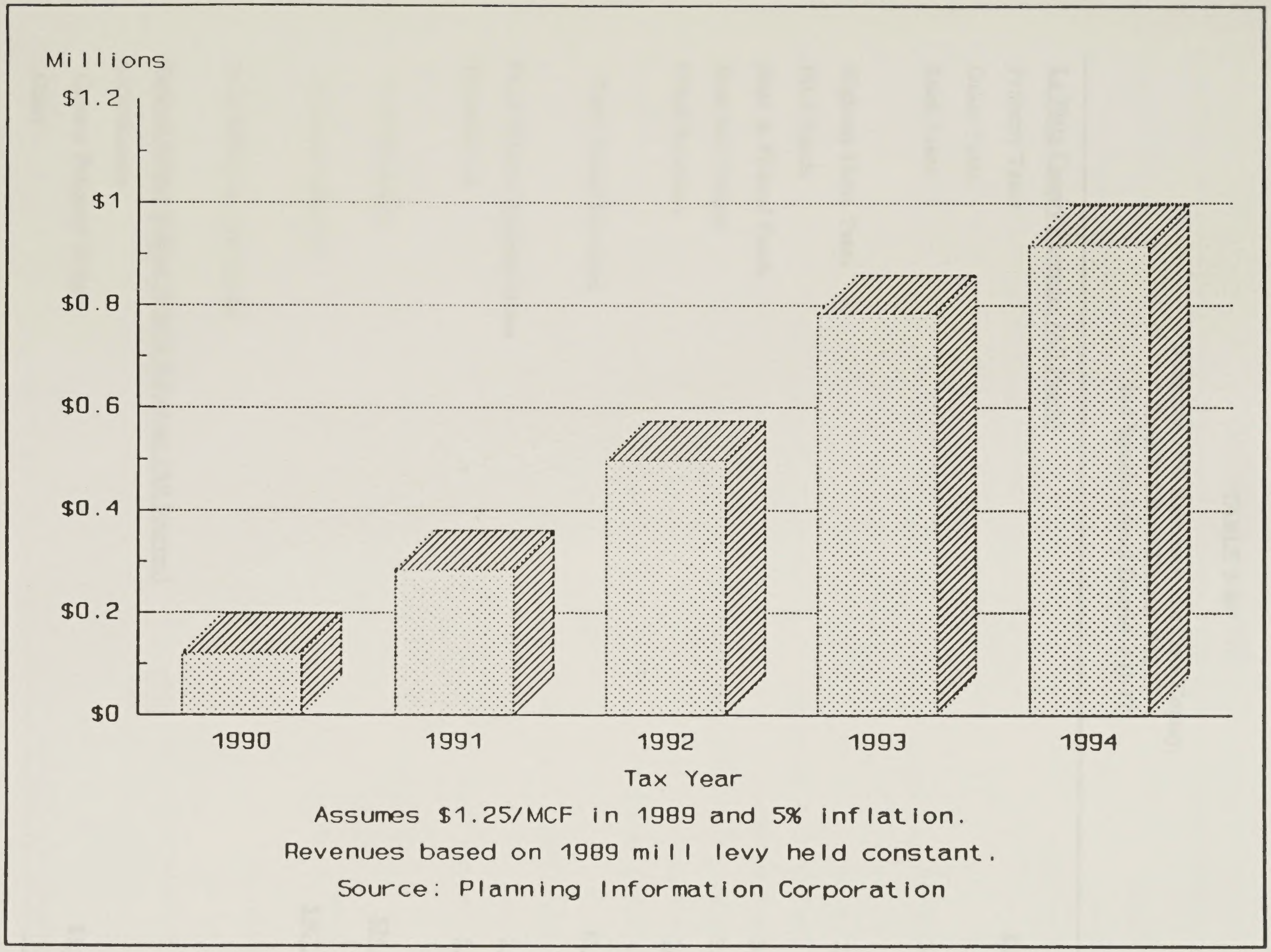


FIGURE 3-26
ESTIMATED TAX REVENUE TO LA PLATA COUNTY
FROM PROJECTED FRUITLAND COALBED METHANE PRODUCTION

TABLE 3-36

Budgeted 1990 Revenues: La Plata County,
Bayfield School District #10-JT
and Ignacio School District #11-JT

La Plata County Revenues (All Funds)	
Property Taxes	$3,137,362
Other Taxes	214,000
Sales Taxes	3,550,000
Highway Users Taxes	1,280,000
PILT Funds	150,000
State & Federal Funds	3,649,133
Fees and Charges	2,381,497
Other Revenues	1,153,130
Total Actual Revenues	15,515,122
Fund Balance Appropriations	2,806,473
Transfers - In	5,707,500
Total Resources	$24,029,095
Assessed Valuation	$367,288,640
Total Mill Levy (All Funds)	8,424
Bayfield School District #10-JT Revenues (All Sources)	
Local Sources	
Current Property Taxes	$1,505,008
Other	119,300
Subtotal	1,624,308

22271/R1T336 10-16-90/22271-4

TABLE 3-36 (Continued)

County Sources	9,300
State Sources	
State Equalization	1,285,147
Other	97,167
Subtotal	1,382,314
Federal Sources	5,000
Total Fund Revenues All Sources	$3,020,922
Beginning Fund Balance	$ 253,878
Total Beginning Fund Balance and Revenues	3,274,800
Assessed Valuation	37,575,760
Total Mill Levy (All Funds)	44,551
Igancio School District #11-JT Revenues (All Sources	
Local Sources	
Current Property Taxes	$ 1,497,043
Other	363,500
Subtotal	1,860,543
County Sources	10,000
State Sources	
State Equalization	1,927,331
Other	162,000
Subtotal	2,089,331

TABLE 3-36 (Continued)

Federal Sources	580,000
Total Actual Revenues	$4,539,874
Beginning Fund Balance	$2,370,500
Total Beginning Fund Balance and Revenues	6,910,374
Assessed Valuation	40,044,820
Total Mill Levy (All Funds)	35,027

Attitudes and opinions concerning current and historic oil and gas development are discussed in three categories for the purpose of this analysis. These categories include attitudes and opinions held by the following groups: those who support oil and gas development (primarily on economic grounds); those who are concerned about potential environmental and aesthetic effects of oil and gas development; and certain residents of areas near coalbed methane development who perceive that their lives and property have been directly affected by development activities.

These categories are used for ease of analysis; they are not necessarily mutually exclusive. It is possible for one person to have attitudes and opinions described in several categories (in fact, it was not uncommon for an informant to observe that he or she supported development of the coalbed methane resource if it could be accomplished without damaging the environment or quality of life). Similarly, it is possible for a person to share some, but not all, of the attitudes and opinions described under a particular category.

Many La Plata County residents support development of the coalbed methane resource, citing the history of the oil and gas industry in the county and the need to diversify the economy and the tax base. Recent events, such as the fire in the roundhouse of the Durango and Silverton Narrow Gauge Railroad, have heightened local awareness of the risks associated with primary dependence on a single industry.

Many residents have also expressed concern about the environmental effects of coalbed methane development. Chief among these concerns is the potential for ground water contamination by methane or by the disposal of water produced from coalbed methane wells. This concern has been heightened by the discovery of methane in a number of wells near the settlements of Bondad, Colorado, and Cedar Hill, New Mexico, and the discovery of methane seeps in the Animas River near these areas. At the time of this analysis, the source of the contamination has not been identified (Durango Herald, May 22, 1989; Colorado Oil and Gas Conservation Commission 1989).

Many of the residents of the portion of La Plata County that lies between the Los Piños (Pine) River and the San Juan National Forest originally moved to the area because of the scenic beauty and rural environment. While many of these residents may commute to Durango for work, they live in rural La Plata County because they value the rural lifestyle. Many of these residents are becoming increasingly dissatisfied with the industrial and natural resource development activities that are occurring in the eastern portion of the county.

Some residents of areas in which drilling and related activities associated with coalbed methane development have occurred have identified the following impacts to their lifestyles: dust, noise, safety, and road damage effects generated by heavy truck traffic on rural roads; and noise and visual effects associated with drilling, compression, and produced water disposal facilities. There is concern among some residents of these areas about contaminated wells and safety issues. Dissatisfaction has also been expressed concerning the conflicts between oil and gas development activities and the use of NFS lands for recreation and leisure activities.

Some area residents are also concerned that property values may deteriorate as land uses in eastern La Plata County change from agricultural and rural residential to low-density industrial and natural resource development. Residential property adjacent to oil and gas developments will experience a decline in value, in the opinion of some area real estate agents, particularly if the oil and gas activities can be seen or heard from the residential properties. However, at the time of this analysis, the La Plata County Assessor has not observed effects of oil and gas development on property values in either transactions that have occurred or in the real estate market (Larsen, personal communication, 1990).

Some coalbed methane development has occurred on private property where the property owner does not own the underlying mineral rights. These underlying mineral rights are superior to those rights of the surface owner. In some cases, this development has resulted in conflicts between property owners and companies. Other area residents who do not own mineral rights are concerned that such development may occur on their property.

A common theme among those affected by development is that they had moved to the rural areas of the county to escape urban and industrial development. They perceive the current coalbed methane development activities occurring near their homes as contrary to the values which brought them to the area. Several informants suggested that they would try to sell their homes and relocate to an area of the county that was not subject to oil and gas development.

Some informants were frustrated with what they perceived to be a lack of authority or willingness to address their concerns among the several agencies responsible for regulating coalbed methane development.

Other environmental and aesthetic concerns include potential effects on wildlife, surface water, traffic, air quality, historic resources, noise, and visual effects on rural land.

Organizational responses to the above concerns include the establishment by La Plata County of regulations for oil and gas development, an agreement by the U.S. Environmental Protection Agency to recommend new policies prohibiting the shallow disposal of gas well wastewater, a campaign led by local environmental and citizen's organizations for a cumulative study of the effects of coalbed methane development in the San Juan Basin, and the organization of a clearinghouse committee of agencies that regulate oil and gas development in the San Juan Basin.

An analysis of the potential environmental and socioeconomic consequences that would result from implementation of Amoco's proposed action or the alternatives is provided in this chapter of the EIS. The effects of facilities construction, operation, and abandonment are considered in the analyses for all resources/disciplines. Project facilities or components include access road construction and maintenance, flowlines installation and reclamation, well pad construction, well drilling and completion/testing, gas treatment and compression, and produced water collection, transportation, and disposal. Measures that would avoid or reduce impacts have been included in Amoco's proposed action (see Chapter 2). Additional measures to be required by the FS and BLM are presented in Appendix A of this EIS. The following impact assessment takes into consideration these mitigation measures; where appropriate, the assessment identifies impacts with and without mitigation. Additional mitigation, beyond the measures proposed by Amoco or required by the FS and BLM, are identified by resource/discipline in this chapter and summarized in Chapter 6 of this EIS.

Given the complexity of the alternatives in terms of facility numbers and types, and the desire to quantify impacts as much as possible, a specific approach was developed to assess impacts to surface resources (soils, geologic hazards, vegetation, timber, grazing, wildlife, visuals, cultural, land use, transportation, and recreational resources) which would be disturbed by the installation of facilities. This approach was generally followed by all affected surface resources, but modified as necessary to adapt to their resource. The approach was as follows:

- An initial disturbance area of 3 acres was defined per well pad within a well window of approximately 40 acres.

- Three acres of high resource sensitivity to project implementation was assigned for each well window which contained three or more acres of mapped high sensitivity for that specific resource.

- Acres of high sensitivity were determined for resources crossed by a 50-foot wide transportation ROW system which would access proposed well sites; the transportation ROW consists of areas to be disturbed by the construction and operation of an access road and the subsurface installation of flowlines.

- Acres of high sensitivity were determined for resources crossed by a 600-foot wide corridor system centered on the proposed 50-foot wide transportation ROW; impacts were assessed based on the possible lateral relocation of the transportation ROW up to 275 feet within the corridor.

Methods and areas of analysis for the remaining resources/disciplines including water, air quality, noise, socioeconomics, and health and safety varied according to the nature of the resource/discipline.

The description of the environmental consequences for each resource/discipline section in this chapter includes the following subsections: **Introduction** - describes the type and range of potential impacts that could result from project implementation, identifies any areas of sensitivity for the resource/discipline, and discusses any regulatory framework or stipulations which mandate the application of mitigation measures; **Direct and Indirect Impacts** - area- and/or site-specific assessment, and quantification where possible, of impacts; **Impacts Summary** - comparison of impacts that occur under each alternative; **Cumulative Impacts** - definition of impacts likely to result from implementation of one of the alternatives in combination those impacts of past, on-going, and foreseeable activities or projects; **Mitigation Summary** - listing of measures that could be applied to avoid or reduce impacts, particularly those measures not proposed by Amoco or presented in Appendix A; and **Unavoidable Adverse Impacts** - impacts that are unavoidable and unmitigable, and therefore, would remain for the duration, and in some cases, beyond the life of the project.

4.1 SOILS AND GEOLOGIC HAZARDS

4.1.1 Introduction

Impacts to soils from the construction of well pads and linear access roads and flowlines would include:

- Removal of protective vegetative cover and loss of soil productivity;
- Loss of soil profile development due to mixing of soil horizons and break-down of soil structure; and
- Increased exposure of surface soil materials to accelerated erosion.

Such adverse impacts would likely result from the clearing of vegetation and the blading/leveling of lands preceding facility construction. Blading and/or excavation of areas to achieve desired grades can result in slope steepening of exposed soils in cuts and fills, mixing of soil materials, and the breakdown of soil aggregates into loose soil particles. Soil structural aggregates can also be broken-down by compaction from vehicular traffic. Well pads and access road surfaces would be covered with a layer of gravel.

Absence of vegetative cover, steepening of slopes, and the breakdown of aggregates by crushing during compaction or excavation would result in increased potentials for both sheet and channelized runoff and soil erosion. Similar disturbances to soils in areas of natural or created (cut and fill slopes) surface and/or subsurface instability would increase the potential for mass soil or geologic material movement and/or continued high rates of erosion and soil loss. Such impacts could in turn have adverse effects on the construction and operations of facilities. Soil erosion or mass wasting could result in damage to facilities including well pads, access roads, and flowlines.

Of the various types of soils and geologic impacts, areas prone to periodic flooding, undergoing severe erosion; subject to landslides, located on steep slopes (greater than 40 percent); and/or located in areas of high water erosion potential are considered most sensitive. The locations of these high-sensitivity areas were factored into the proposed locations of access roads and flowlines. The distribution of areas of high sensitivity to disturbance is presented on Figure 4-1. This figure shows areas of high sensitivity based on propensity to flood (FS and SCS 1981), presence of landslide deposits and/or favorable conditions for slides to occur, and severe erosion/-soil loss conditions (see Figure 3-2). The distribution of steep, high sensitivity slopes and related difficult revegetation conditions is presented on Figure 4-2. The distribution of areas with high erosion hazard or sensitivity is presented on Figure 4-3.

Implementation of standard mitigation measures normally attached by the Forest Service (FS) and Bureau of Land Management (BLM) to their approval for construction and operation of a pipeline/flowline or an application for permit to drill (APD) would generally minimize impacts to soils (Appendix A). Mitigation measures include topsoil salvage and protection, revegetation, and safe handling and storage of fuels, lubricants, and other liquids/materials to prevent spills and subsequent soil contamination.

4.1.2 Direct and Indirect Impacts

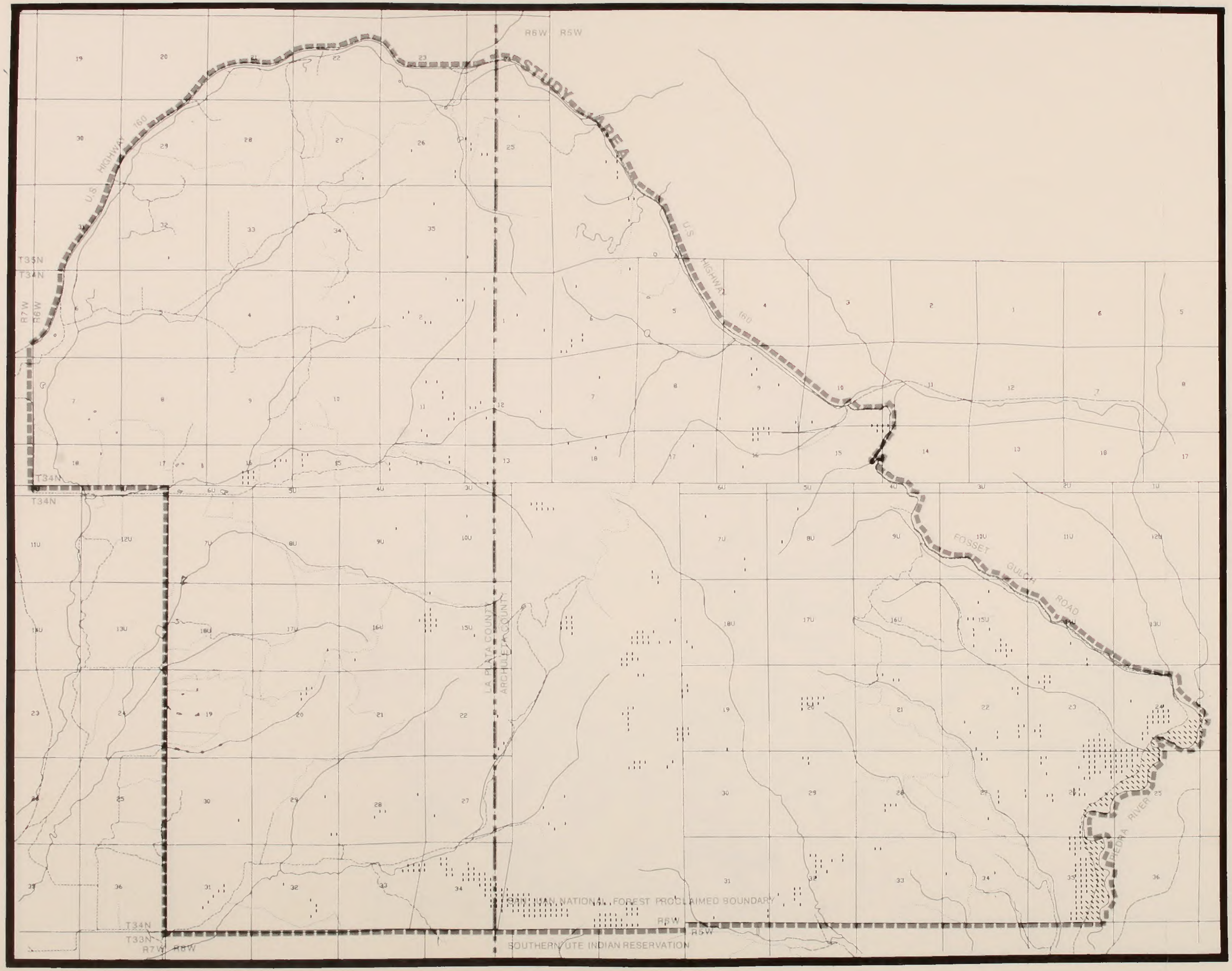
4.1.2.1 Alternative A - No Action

Construction. Alternative A would involve the installation of approximately 19 miles of natural gas and/or produced water flowlines on National Forest System (NFS) lands, and 6.5 miles of flowlines on private lands, for a total of 25.5 miles within the Study Area (Figure 2-1). Single or double flowlines would be placed within a common 20-foot wide construction right-of-way (ROW). Assuming soil disturbance across the ROW, approximately 46 acres on NFS lands and 16 acres on private lands would be affected. Approximately 0.1 acre, 1.5 acres, and 11.4 acres of high-sensitivity areas for surface stability (Figure 4-1), steep slopes (Figure 4-2), and erosion hazard (Figure 4-3), respectively, would be affected on NFS lands. No high-sensitivity areas for surface stability features would be affected on private lands. However, approximately 0.3 acres and 1.7 acres of steep slopes and high erosion hazard would be affected, respectively, on private lands.

Soil profile development within the trench would be lost; however, replacement of subsoil followed by topsoil to the surface as likely to be required on NFS lands (Appendix A-1) would restore a suitable plant growth medium. Stipulated treatment of compaction, implementation of revegetation, and use of erosion control features would limit the effects of flowline construction to the short-term as mitigation measures would stabilize soil materials, promote the reestablishment of vegetation, and restore soil productivity (Appendix A-1). Mitigation measures stipulated for use on NFS lands could serve as guidance for measures to be implemented on private lands.

Operations. Maintenance checks during operations of the installed flowlines may disturb the soils of the reclaimed ROW; however, the effects would be expected to be minor and of limited extent. Any such disturbances would be required to be promptly mitigated.

Existing natural gas production facilities and FS gravel and dirt roads are the principal sources of long-term disturbance to soils on NFS lands within the Study Area. Natural gas production facilities consisting of compacted and graveled well pads and access roads occupy approximately 46 acres on NFS lands. Although used by the natural gas production companies, most gravel and dirt roads are part of the FS network of roads in the HD Mountains. FS roads provide access for a variety of purposes, in keeping with the Multiple Use concept for NFS lands. The FS roads in the Study Area occupy about 135 acres. Combined, the gas production facilities and the FS roads occupy a total of about 180 acres of NFS lands. This acreage represents approximately 0.4 percent of NFS lands and about 0.3 percent of the Study Area.



SURFACE STABILITY SENSITIVITY

HIGH SENSITIVITY AREAS
INCLUDE AREAS OF INSTABILITY ASSOCIATED WITH LANDSLIDES, AREAS UNDERGOING SEVERE EROSION, AND AREAS SUBJECT TO PERIODIC FLOODING

AREAS OF HIGH SENSITIVITY

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

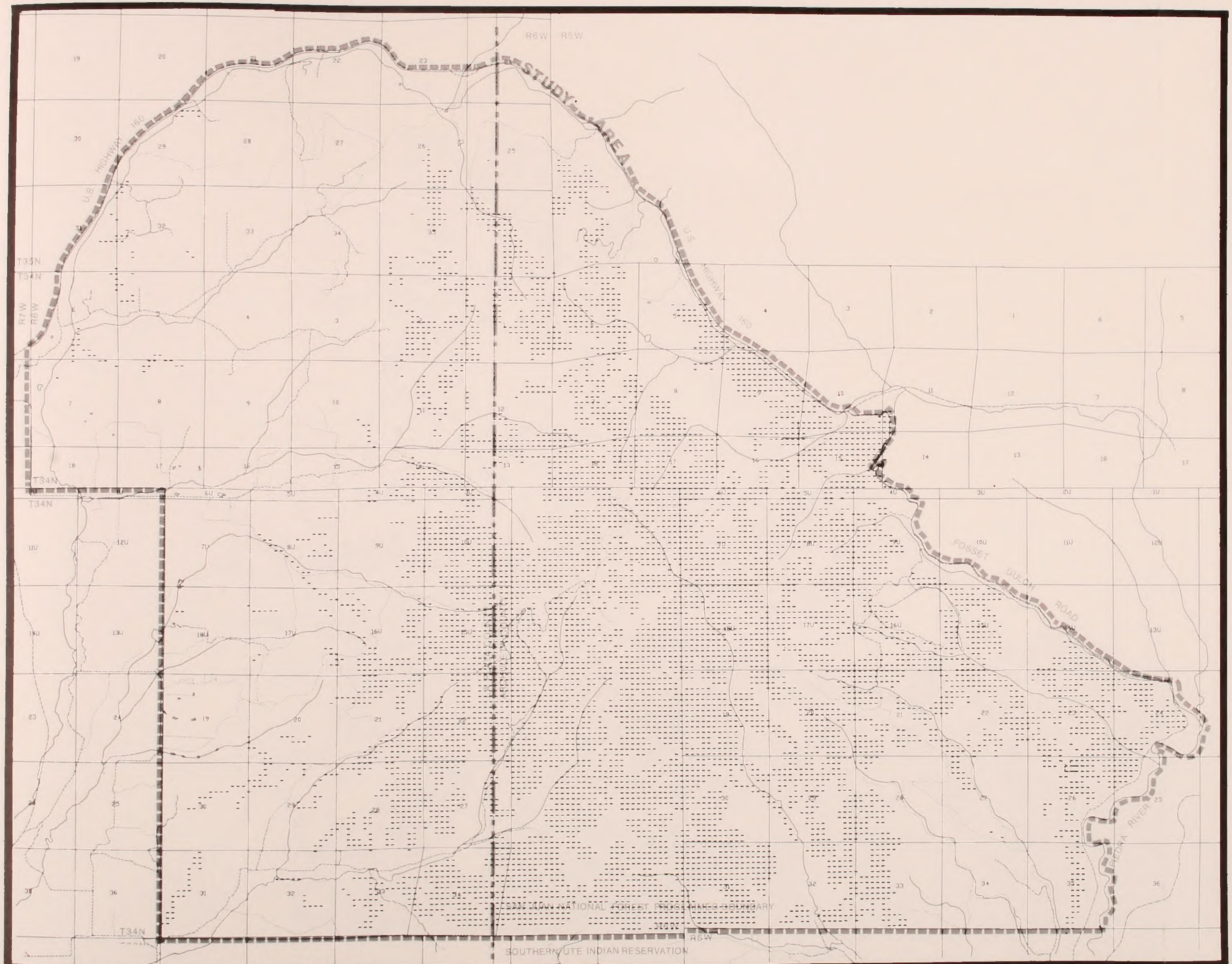
ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 4-1



SLOPE SENSITIVITY

HIGH SENSITIVITY AREAS
INCLUDE AREAS WITH
SLOPES GREATER THAN 40 PERCENT

- AREA OF HIGH SENSITIVITY

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

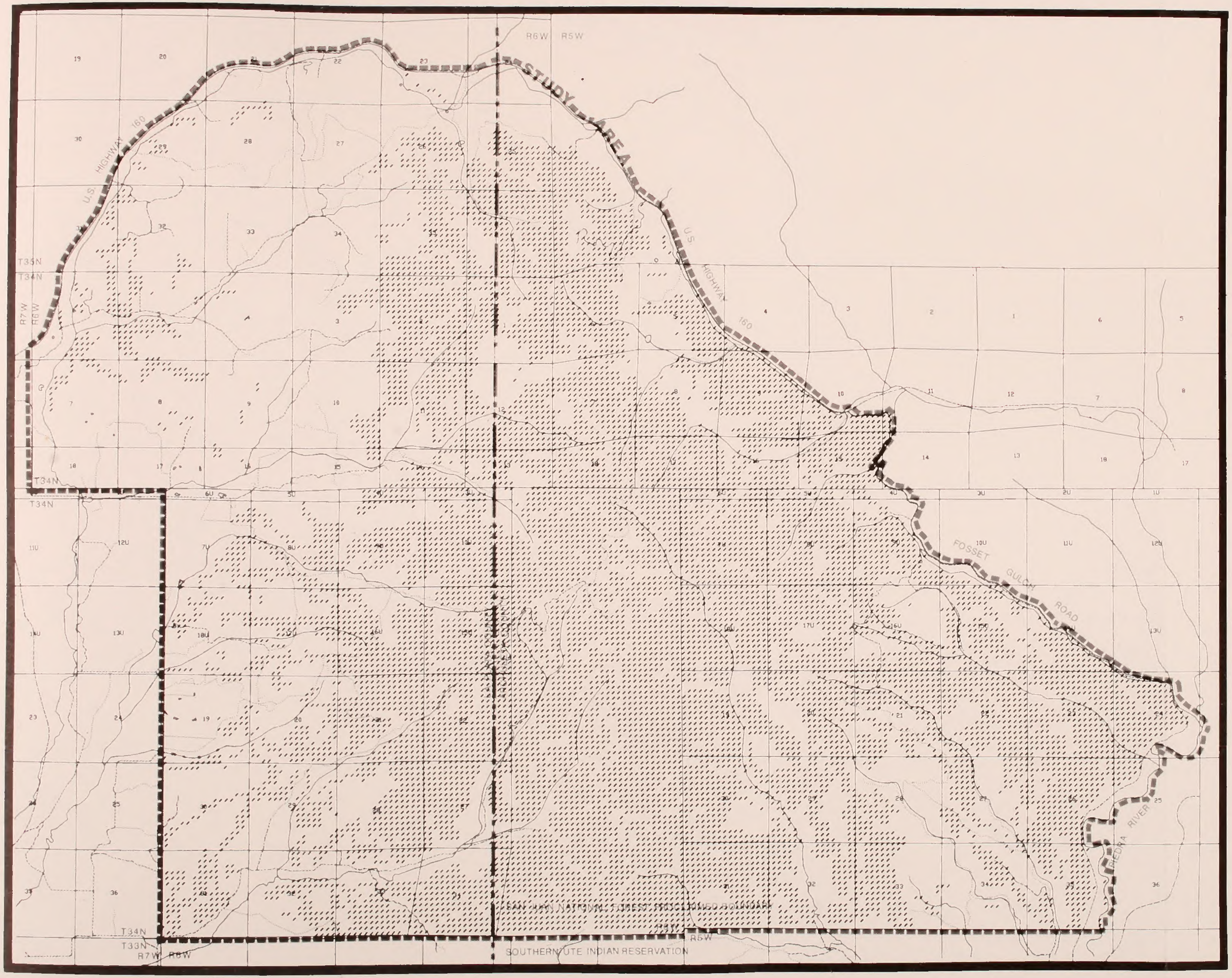
ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE **4-2**



EROSION HAZARD SENSITIVITY

HIGH SENSITIVITY AREAS INCLUDE AREAS OF HIGH SOIL EROSION HAZARD

/ AREA OF HIGH SENSITIVITY

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 4-3

Soils of areas occupied by both the gas production facilities and the FS roads are compacted and covered, in the case of well pads and gravel roads, with a gravel surface to provide vehicular access under most weather and soil moisture conditions. The graveled areas are lost to vegetative production for the duration of use for the well pad and access road; however, the gravel surface serves to armor the overlain soil materials against erosion. The dirt roads are less protected and require more frequent maintenance during regular use.

Other than use of well pads, graveled access roads, and FS gravel and dirt roads by vehicles, current well field production activities have little, if any, impact on surrounding soils. Contamination of soils beneath graveled surfaces or comprising the dirt road surface by leaking or spilled fuels or lubricants is possible, but would likely be of minimal extent and impact.

Abandonment. Well field production facilities, including well pads and access roads, would be abandoned with the cessation of natural gas production operations. The graveled surface of well pads would be removed and the soil surface would be scarified to a minimum depth of 4 inches in preparation for revegetation (Appendix A-4). Roads, including any gravel surface constructed for the sole purpose of accessing wells, would be removed and impacts mitigated as defined above for well pads. Flowlines would be abandoned in place with no additional disturbance to soils.

4.1.2.2 Alternative B - Proposed Action

Construction. The drilling of 28 wells on NFS lands within the Study Area would result in the initial disturbance of 84 acres of soils previously undisturbed by man's activities other than livestock grazing. Five of the 28 proposed wells have known exact locations within the well windows; the remaining 23 wells would be located somewhere within their respective windows (Figure 2-2). For the five known well locations, no areas of high sensitivity for surface stability, slope, or erosion hazard would be affected by well construction (Figures 4-1, 4-2, and 4-3). For the remaining 23 well windows, six acres, 27 acres, and 57 acres of high-sensitivity areas for surface stability, slope, and erosion hazard, respectively, would be affected in the short-term. These acreage figures represent the occurrence of a minimum of three acres of high sensitivity for surface stability, slope, and erosion hazard in two windows, nine windows, and 19 windows, respectively (Figures 2-2, 4-1, 4-2, and 4-3).

Alternative B would also include the drilling of six wells on private lands within the Study Area (Figure 2-2). Construction of the six well sites would affect approximately six acres, six acres, and 15 acres of high-

sensitivity areas for surface stability, slope, and erosion hazard, respectively (Figures 2-2, 4-1, 4-2, and 4-3). These acreage figures represent the occurrence of a minimum of three acres of high sensitivity for surface stability, slope, and erosion hazard in two windows, two windows, and five windows, respectively (Figures 2-2, 4-1, 4-2, and 4-3).

Construction of access roads and flowlines on NFS lands would involve an initial disturbance to soils across a 50-foot wide transportation ROW; however, the road bed would occupy only 20 feet of the 50-foot width, with the soils of the remaining 30 feet of ROW to be stabilized and revegetated immediately after road and flowlines construction. The proposed transportation network for Alternative B would traverse 0.5 miles, 4.3 miles, and 10.7 miles of high-sensitivity areas for surface stability, slope, and erosion hazard, respectively (Figures 2-2, 4-1, 4-2, and 4-3). Corresponding acreages initially affected would be approximately 2.8 acres, 26 acres, and 65 acres. Although locations of access roads and flowlines ROW on private lands have not been proposed, potentially 4.5 miles of transportation ROW would be constructed, based on an estimate of 0.75 miles of linear 50-foot wide ROW per well for the six wells, affecting about 27 acres of soils.

Should the 50-foot wide transportation ROW be moved up to 275 feet off the proposed center line during final staking, analysis of the 600-foot wide corridor system indicates impacted acreages of high-sensitivity areas would remain about the same as defined above. Percent composition of high-sensitivity areas for surface stability, slope, and erosion hazard for the acreage totals for the proposed 50-foot wide ROW network and for the 600-foot wide corridor network are 2 percent and 2 percent, 18 percent and 19 percent, and 46 percent and 46 percent, respectively (Figures 2-2, 4-1, 4-2, and 4-3).

Alternative B would also include the construction of flowlines to existing wells, as described in Section 4.1.2.1. Affected acreages of high-sensitivity areas for surface stability, slope, and erosion hazard are the same as described previously, as is the applicability of standard mitigation measures (Appendix A-1).

Implementation of standard mitigation measures (Appendixes A-1 and A-4) and sound practices for construction of well pads, access roads, and flowlines on NFS lands would reduce impacts related to surface stability, steep slopes, and high erosion hazards. Remaining long-term impacts to soils would be (1) the loss of soil development for all 28 wells (84 acres) and the transportation network (141 acres), and (2) lost soil productivity of 56 acres (2 acres per well site) for well pads and 56 additional acres of graveled road surface for the 30-year life of operations.

Operations. Use of well pads and access roads for the 30-year life of operations would result in minimal additional impacts to soils beyond those described above for construction. Such impacts could include increased runoff from compacted and graveled well pad and road surfaces, and subsequent increased sheet and channelized erosion down gradient. Any spills or leaks of fuels, lubricants, produced water, or drilling fluids could result in localized contamination of soils beneath the gravel surface. However, implementation of sound operational practices and mitigation measures, including spill cleanup measures outlined in Appendix A-4, would minimize the magnitude and extent of such impacts.

Maintenance checks and/or repairs of flowlines could disturb the soils of the reclaimed/revegetated ROW; however, the effects would be expected to be minor and of limited extent. Any such disturbances to soils would be promptly mitigated (Appendix A-1).

Abandonment. Abandonment of constructed and operated well field facilities proposed in the Alternative B development scenario would have the same effects and use the same mitigation measures as those discussed for Alternative A (Section 4.1.2.1).

4.1.2.3 Alternative C - Current Direction

Construction. The drilling of 95 wells on NFS lands within the Study Area would result in the initial disturbance of 285 acres of soils previously undisturbed by man's activities other than livestock grazing. Five of the 95 proposed wells have known exact locations within the well windows and would not occur in areas of high sensitivity impacts, as described in Section 4.1.2.2. For the remaining 90 well windows, 15 acres, 165 acres, and 201 acres of high-sensitivity areas for surface stability, slope, and erosion hazard, respectively, would be affected for the short-term (Figures 2-7, 4-1, 4-2, and 4-3). These acreages represent the occurrence of a minimum of three acres of high sensitivity for surface stability, slope, and erosion hazard in five windows, 55 windows, and 67 windows, respectively.

Alternative C would also include the drilling of 20 wells on private lands and one well on state lands within the Study Area (Figure 2-7). Construction of the 21 wells on non-NFS lands would affect about 12 acres, 15 acres, and 36 acres of high-sensitivity areas for surface stability, slope, and erosion hazard, respectively (Figures 2-7, 4-1, 4-2, and 4-3). These acreages represent the occurrence of a minimum of three acres of high sensitivity for surface stability, slope, and erosion hazard in four windows, five windows, and 12 windows, respectively (Figures 2-7, 4-1, 4-2, and 4-3).

Construction of access roads and flowlines on NFS lands would result in effects described in Section 4.1.2.2. The transportation network for Alternative C would traverse about 0.9 miles, 13 miles, and 27 miles of high-sensitivity areas for surface stability, slope, and erosion hazard, respectively. Corresponding acreages affected initially would be approximately 5.7 acres, 79 acres, and 165 acres. Although locations of access roads and flowlines ROW on private and state lands have not been proposed, potentially 25.5 miles or 124 acres of transportation ROW would be constructed based on previous means of estimation (Section 4.1.2.2).

Should the 50-foot wide transportation ROW be moved as much as 275 feet off the center line during final staking, analysis of the 600-foot wide corridor system indicates impacted acreages of high-sensitivity areas would likely remain the same for surface stability, but increase for both slope and erosion hazard. Percent composition of high-sensitivity areas for surface stability are again 2 percent and 2 percent of the 50-foot wide ROW and the 600-foot wide corridor networks, respectively, as per Alternative B; however, percent composition of high-sensitivity areas for slope and erosion hazard are 25 percent and 40 percent, and 50 percent and 80 percent, respectively (Figure 2-7, 4-1, 4-2, and 4-3).

Alternative C would also include the construction of flowlines to existing wells as described in Section 4.1.2.1. Affected acreages for high-sensitivity areas for surface stability, slope, and erosion hazard are the same as described previously, as is the applicability of standard mitigation measures (Appendix A-1).

Implementation of required mitigation measures (Appendixes A-1 and A-4) and best-management practices for well pads, access roads, and flowlines on NFS lands would reduce impacts related to surface stability, steep slopes, and high erosion hazard (BLM and FS 1989). Remaining long-term impacts to soils would be (1) the loss of soil development for all 95 wells (285 acres) and transportation network (315 acres), and (2) lost soil productivity of 190 acres (2 acres per well site) for the well pads and 126 acres of graveled road surface for the 30-year life of operations.

Operations. Use of well pads and access roads, and operation and maintenance of flowlines, would result in impacts to soils similar to those described in Section 4.1.2.2. Mitigation measures identified in Appendixes A-1 and A-4 would reduce the effects of facility operations on soils.

Abandonment. Abandonment of constructed and operated well field facilities proposed in the Alternative C development scenario would have the same effects and necessitate the same mitigation measures as those discussed for Alternative A (Section 4.1.2.1).

4.1.3 Impacts Summary

Primary impacts to current soil, topographic, and geologic conditions resulting from implementation of an alternative would be the:

- Removal of protective vegetative cover;
- Mixing and compaction of soil materials;
- Exposure of soil materials and slopes to conditions favorable to erosion and mass wasting; and
- Loss of vegetative productivity.

Implementation of Alternative A on NFS lands would result in the long-term loss of soil profile development in bladed, trenched, and/or compacted portions of the flowlines ROW. Assuming the loss would extend across the complete ROW, approximately 46 acres would be impacted (Table 4-1). Soil productivity would be temporarily lost for the same 46 acres. Flowlines construction would affect areas of high sensitivity for surface stability, slope, and erosion hazard (Table 4-1); however, application of sound facility construction practices and mitigation measures outlined in Appendix A-1, commonly referred to as "best-management practices," and supplemental measures listed in Section 4.1.5, would greatly reduce all impacts except those for lost profile development (Table 4-1).

Past construction of existing well sites and roads has resulted in the long-term effects to soil profile development and productivity for 180 acres. This acreage is currently surfaced with gravel and/or maintained for use by vehicles. Acreages of high-sensitivity areas for surface stability, slope, and erosion hazard which appear to have been initially affected by the existing facilities are presented in Table 4-2. Impacts in these high-sensitivity areas have been minimized by using appropriate construction and mitigation measures. Installed flowlines have been or are in the process of being revegetated using standard measures (Appendix A-1) that minimize long-term impacts.

TABLE 4-1

ACRES OF IMPACT TO SENSITIVE SOIL RESOURCES, SLOPES, AND GEOLOGIC HAZARDS FOR PROPOSED FACILITIES ON NFS LANDS

Facility High Sensitivity Parameter	Alternatives A		B		C	
	w/o mit[1]	w/mit[2]	w/o mit	w/mit	w/o mit	w/mit
Well Sites						
Soil Profile Development	NA[3]	NA	84	84	285	285
Soil Productivity	NA	NA	84	56	285	190
Surface Stability	NA	NA	6	0[4]	15	0
Slope	NA	NA	27	0	165	0
Erosion Hazard	NA	NA	57	0	201	0
Transportation ROW						
Soil Profile Development	NA	NA	141	141	315	315
Soil Productivity	NA	NA	141	56	315	126
Surface Stability	NA	NA	2.8	0	5.7	0
Slope	NA	NA	26	0	79	0
Erosion Hazard	NA	NA	65	0	165	0
Flowlines ROW						
Soil Profile Development	46	46	46	46	46	46
Soil Productivity	46	0	46	0	46	0
Surface Stability	0.1	0	0.1	0	0.1	0
Slope	1.5	0	1.5	0	1.5	0
Erosion Hazard	11.4	0	11.4	0	11.4	0

1 without mitigation measures applied
2 with mitigation measures applied
3 not applicable
4 zero acres with mitigation measures applied assumes, where necessary, the successful application and maintenance of effective mitigation measures; minor areas may initially or subsequently fail, but will be appropriately mitigated in a timely manner

TABLE 4-2

ACRES OF IMPACTS TO SENSITIVE SOIL RESOURCES, SLOPES, AND GEOLOGIC HAZARDS FOR EXISTING FACILITIES ON NFS LANDS

Facility High Sensitivity Parameter	w/o mit[1]	w/mit[2]
Well Site		
Soil Profile Development	46	63
Soil Productivity	46	45
Surface Stability	0	0[3]
Slope	2.1	0
Erosion Hazard	6.4	0
Existing Roads		
Soil Profile Development	135	135
Soil Productivity	135	135
Surface Stability	1.1	0
Slope	17	0
Erosion Hazard	50	0
Flowlines ROW		
Soil Profile Development	ND[4]	ND
Soil Productivity	ND	0
Surface Stability	ND	0
Slope	ND	0
Erosion Hazard	ND	0

1 without mitigation measures applied - residual area of impact
2 with mitigation measures applied - remaining area of impact
3 zero acres with mitigation measures applied assumes, where necessary, the successful application and maintenance of effective mitigation measures; minor areas may initially or subsequently fail, but will be appropriately mitigated in a timely manner
4 not determined

Implementation of Alternative B or Alternative C on NFS lands would result in similar types of impacts to soils as described above; the additional well site and access road development for each alternative would result in similar effects. Acreages of disturbance to soils and high-sensitivity areas are presented in Table 4-1. Again, mitigation would reduce or minimize the effects for all but soil profile development (Table 4-1).

Initial disturbance to soils and long-term effects to soil profile development would total 46 acres for Alternative A, 271 acres for Alternative B, and 646 acres for Alternative C (Table 4-1). With mitigation, long-term impacts to soil productivity would be reduced to essentially none for Alternative A, 112 acres for Alternative B, and 316 acres for Alternative C. Initial impacts to high-sensitivity areas for surface stability, slope, and erosion hazard would be 0.1 acres, 1.5 acres, and 11.4 acres for Alternative A; 8.9 acres, 55 acres, and 133 acres for Alternative B; and 21 acres, 246 acres, and 375 acres for Alternative C, respectively. Use of sound construction practices and application of mitigation measures would reduce impacts to these areas of high sensitivity to essentially none for the long-term.

4.1.4 Cumulative Impacts

Cumulative impacts to soils, topography, and geologic conditions on NFS lands would result from the implementation of an alternative in addition to the existing level of impact. Existing well sites and FS multipurpose roads are the source of existing and continuing impact. Combined acreages for existing facility disturbance and each of the alternatives, without and with mitigation, is presented in Table 4-3.

4.1.5 Mitigation Summary

Mitigation measures stipulated by the FS and the BLM and attached to their approvals of APDs (Appendixes A-1, A-2, A-3, and A-4) would likely eliminate or reduce most impacts to acceptable levels. Additional mitigation measures that should be applied include the following:

- Mulch must be crimped into the soil surface on the contour for reclaimed and seeded slopes, up to the slope limit of the crimping equipment.

- Mulched slopes too steep for mechanical crimping must be bound with a sprayed tackifier or covered with a tacked netting, as appropriate, to hold the mulch in place.

TABLE 4-3

ACRES OF CUMULATIVE IMPACTS TO SENSITIVE SOIL RESOURCES, SLOPES, AND GEOLOGIC HAZARDS FOR EXISTING AND PROPOSED FACILITIES ON NFS LANDS

Facility High Sensitivity Parameter	Alternatives					
	A		B		C	
	w/o mit[1]	w/mit[2]	w/o mit	w/mit	w/o mit	w/mit
Well Site						
Soil Profile Development	45	45	129	129	330	330
Soil Productivity	45	45	129	101	330	235
Surface Stability	0	0[3]	6	0	15	0
Slope	2.1	0	29	0	167	0
Erosion Hazard	6.4	0	63	0	207	0
Transportation ROW						
Soil Profile Development	135	135	276	276	450	450
Soil Productivity	135	135	276	191	450	261
Surface Stability	1.1	0	3.9	0	6.8	0
Slope	17	0	43	0	96	0
Erosion Hazard	50	0	115	0	213	0
Flowlines ROW						
Soil Profile Development	46	46	46	46	46	46
Soil Productivity	46	0	46	0	46	0
Surface Stability	0.1	0	0.1	0	0.1	0
Slope	1.5	0	1.5	0	1.5	0
Erosion Hazard	11.4	0	11.4	0	11.4	0

1 without mitigation measures applied
2 with mitigation measures applied
3 zero acres with mitigation measures applied assumes, where necessary, the successful application and maintenance of effective mitigation measures; minor areas may initially or subsequently fail, but will be appropriately mitigated in a timely manner

- Avoid placement of facilities on unstable slopes or surfaces.

- Conduct geologic and geotechnical studies of sufficient detail to develop site-specific engineering designs, and implement appropriate construction for necessary crossings of areas of slope instability.

4.1.6 Unavoidable Adverse Impacts

Unavoidable long-term loss of soil profile development would occur with the construction of facilities and the necessary disturbance of in-place soils. Soil productivity (vegetative) would be lost during the short-term in areas temporarily cleared of vegetation for construction but revegetated shortly after construction is completed. Soil productivity would be lost for the life of well pads and roads, but would be restored after abandonment. Soil loss due to erosion would likely increase during construction and for a period of time after reclamation, until adequate vegetative cover is established.

4.2 WATER RESOURCES

4.2.1 Introduction

Field development of coalbed methane resources includes three general areas of potential impact to surface and ground water resources: construction impacts, impacts during operations, and impacts associated with abandonment. Impacts to surface water from the construction of well pads, access roads, and flowlines could include increased overland flow, with subsequent erosion and offsite sedimentation due to the removal of vegetation, exposure of the soil surface, and compaction of the soil. Potential impacts related to operations include the accidental release of produced water, natural gas, fuel, lubricants, and solvents from pipelines and holding pits during operation. These changes would occur along segments of new access roads in proximity to stream channels, creating the potential for increased runoff, increased stream sedimentation, channel scour, bank erosion, stream bed alteration, and subsequent degradation of water quality. Impacts associated with abandonment could occur from minor construction activities and the reclamation of the surrounding area.

The magnitude and duration of these impacts would depend on several factors; including slope, aspect, and gradient; degree and area of soil disturbance; susceptibility of soil to erosion; and proximity to drainage channels. The duration in which construction activities take place and the timely implementation of mitigation measures and their success or failure would also be factors. Construction impacts would be greatest soon after

the commencement of construction activities, but would naturally decrease shortly afterward due to passive natural stabilization.

Slope destabilization and drainage problems could occur in areas where construction crosses steep slopes. Slumps could occur as a result, and, depending on the proximity to a stream channel, could cause substantial stream sedimentation.

Construction of stream channel crossings could also cause increased stream sedimentation and channel bed disruption resulting in destabilization of the channel, which in turn could cause shifts and readjustments of streamflow hydraulics. The potential impacts to surface water resources include:

- Increased transport of contaminants bound to sediments;
- Scour from additional sediment load;
- Alteration of stream channel;
- Covering of benthic organisms in the stream/river;
- Degraded fish spawning habitat; and/or
- Additional surface area necessary for macrophytic root attachment to substrate.

The leakage or spillage of reserve pit fluids could degrade surface water. The potential of such an impact occurring would depend on the quantity released and the proximity to the water body impacted. Spillage of petrochemicals associated with the construction or operation of the project could also impact surface water if released in close proximity to surface water bodies.

These impacts to surface water could potentially have high sensitivity considerations if:

- Stream water quality is degraded to a point chronically below state water quality numerical standards.

- Overall stream conditions are degraded below minimal considerations necessary to maintain the appropriate state designation and/or classifications (e.g., recreation, aquatic life, etc.).

- Channel morphology is altered sufficiently to produce undesirable effects such as gradation, degradation, or side cutting.

Potential impacts to ground water could occur if:

- Degradation of the quality of ground water contained in fresh water aquifers occurred to the point that it did not meet state standards as itemized by the Rules and Regulations of the Water Quality Division of the Colorado Department of Health, or

- An increase or decrease in ground water levels were to occur, caused by construction, operations, or abandonment of the proposed project.

The magnitude and duration for these impacts to ground water would depend upon the quantity and quality of fluids or methane gas released to the ground water system and the proximity of coalbed methane (CBM) wells to pathways that would allow migration of contaminants into ground water.

Sources of potential ground water contamination could come from coalbed methane wells that are not properly sealed during drilling, production, and abandonment activities to prevent the introduction of contaminants into the ground water. Ground water quality changes could also occur from the leakage of fluids from drilling pits, and spills or leaks from transporting produced water for disposal by trucking or flowlines. Such conditions or events could allow contaminants from the surface to migrate to ground water, to mix poor quality ground water with higher quality ground water, or allow the flow of methane gas from producing zones along well casings to migrate into drinking water zones, domestic wells, or to the surface.

Uranium has been reported in the Fruitland Formation at one location approximately 50 miles southwest of the Study Area (Fassett and Hinds 1971). Radon is often associated with radioactive deposits and may be present locally in the Fruitland Formation. In southwest Colorado, radioactive ores are generally associated with Jurassic Age deposits which are much deeper than the coalbed methane producing zones of the Cretaceous Fruitland Formation. Therefore, the probability of releasing radon gas is low. Furthermore, should radon gas be detected at one location, this does not indicate that it will be detected in adjacent areas (Lammering, personal communication, 1990). Any radon gas tapped by a CBM well would be contained within the closed CBM gas production system; however, should radon gas be released into the atmosphere at a well site, it would likely be a very small quantity and would be quickly dispersed, posing minimal health or environmental risk since exposure to higher levels of radon gas in areas of Colorado is related to confined or closed spaces (i.e., basements).

Amoco's leases contain stipulations concerning the occupation of various portions of the lease area. Stipulations, or FS/BLM Plan of Operations requirements, restricting Amoco with special reference to water resource concerns, are listed below. However, exemptions may be granted upon site-specific investigations (see Section 2.2.2).

- Surface occupation cannot occur within 500 feet of the normal highwater line of any and all lakes, ponds, and reservoirs located in the lease area.

- Surface occupation cannot occur in areas within 500 feet of the normal highwater line of any and all streams in the area or within 400 feet of all springs within the lease area.

- All soil disturbed as a result of this project will have erosion control devices installed when appropriate.

- Water for hydrostatic testing will not be obtained from NFS lands, and such testing will not contaminate the water.

- The permittee shall locate, handle and store gasoline, oil, lubricants, and other liquids or materials and trash in a manner as to prevent them from entering into or contaminating water sources and soil.

- All fresh water encountered during drilling will be recorded by depth, cased, and/or cemented.

- Produced wastewater will be confined to a lined pit for a period not to exceed 90 days after initial production and with a freeboard no less than four feet.

- Immediately report spills, leaks, accidents or any other unusual occurrences.

- Cement bond log will be required should cement fail to circulate to the surface on surface and production casing strings.

- Minimum pressure testing requirements are 2000 psi for ram-type blow-out prevention equipment (BOPE) and 1500 psi for annular BOPE.

- File with the BLM water analysis of the Fruitland Formation (analysis should include major anions, cations, total dissolved solids (TDS), and conductance of produced water sample).

- Record and file with the BLM static water level with completion report (From 3160-4).

- Complete Bradenhead testing for all wells within one-half mile of a proposed well.

- Monitor and record cumulative water production.

- Additional stipulations related to water resources are contained in Appendixes A-1, A-2, A-3, and A-4.

4.2.2 Direct and Indirect Impacts

4.2.2.1 Alternative A - No Action

Construction. The construction of 25.5 miles of new flowlines on both NFS and private lands would likely result in short-term increases of erosion and subsequent sedimentation in intermittent and perennial streams. The degree of soil loss and subsequent sedimentation will vary from site to site and actual loss is difficult to quantify (see Section 4.1 for average estimates). There are eight locations where flowlines are expected to cross streams in the Study Area (Figure 2-1). At the crossings, the risk for increased sedimentation is higher due to the closer proximity of flowlines to the stream. There are also risks if streamflows are high enough to cause flooding or additional erosion of the streambank, which may undermine the foundation of the stream crossing structure.

New flowline construction and connection construction activities would have a low potential of impacting ground water, since the flowline construction would not directly penetrate ground water aquifers. Potential short-term impacts that could occur include surface spills of fuels and other fluids used during construction activities. The magnitude and duration of these impacts would most likely be minimal, since spills would be small, localized, and readily remediated. No potential long-term impacts to ground water from flowline construction is foreseen.

Operations. Surface water impacts that may occur during the operation of the flowline would primarily consist of produced water flowline leaks or spills. The impacts related to these leaks would depend on the proximity

of the leak to the stream or river, by slope, aspect, and grade, and the quantity and quality of the produced water. For leaks that occur underground, impacts may include slumping, increased erosion, and subsequent sedimentation in drainageways; for leaks that occur over drainageways, impacts would depend on the quantity and quality of the produced water.

Operation of new flowlines would have a low potential impact to ground water, since the flowlines most likely would not directly penetrate ground water aquifers used for drinking water purposes. Potential negative impacts due to flowline operation would be ground water contamination from unregulated spills or leaks. Sources of potential impacts would be due to leakage of produced water from joints or cracks in the flowlines and spilling or leakage of fluids from trucks doing maintenance work. The magnitude and duration of such impacts would depend upon the quantity and quality of fluids released. These impacts would most likely be short-term, since the flowlines will be monitored for leaks. Any spills or leaks would be localized and, once detected, immediately reported, and cleanup activities initiated. Since development of coalbed methane wells and flowlines in the HD Mountains, no leaks or spills have occurred from flowlines or produced water trucks on NFS lands (Bell, personal communication, 1990).

No long-term impacts to ground water due to flowline operation are expected.

Abandonment. Abandonment of flowlines would have a low potential of impacting ground water. Sources of potential impacts due to abandonment activities would include unregulated surface spills and leaks from joints or cracks in the flowlines, and from vehicles used during abandonment. Impacts due to abandonment would be short-term and have minimal affect on ground water, since fresh water would be used to flush the lines. Any leaks in the flowlines would have been detected prior to commencing with abandonment activities. Water used to flush the lines will be injected into the disposal well.

No long-term impacts to ground water associated with flowline abandonment are expected to occur.

4.2.2.2 Alternative B - Proposed Action

Alternative B will be comprised of 28 new wells and 23 miles of roads/flowlines. Each well pad is expected to create a surficial disturbance of approximately 3 acres. The 23 miles of combined road and flowlines ROW is expected to disturb an area of approximately 141 acres. Under this alternative, there are expected to be approximately 10 additional stream crossings from flowlines/access roads on NFS lands (Figure 2-2). The actual number of stream crossings may vary depending on the final design of the transportation network.

Construction. Implementation of this alternative would result in approximately 10 additional stream crossings by flowlines/access roads on NFS lands (Figure 2-2). The actual number of stream crossings may vary depending on the final design of the transportation network. The primary potential impacts to surface water would be to water quality resulting from soil erosion from disturbed areas and subsequent sedimentation in streams and rivers. The extent of impact would depend on slope aspect and grade. A minor increase in water runoff due to the addition of an impervious surface may also occur. Additionally, the fuels, lubricants, and solvents used during construction could wash off well pads during rainfall events. Strict control of inputs into reserve pits would be necessary to avoid any Resource Conservation and Recovery Act (RCRA) classification of liquids in the pits.

Construction of the flowlines would occur in the same ROW as the access roads; impacts and mitigation measures to surface and ground water from flowline construction are expected to be similar to access road construction and to those impacts described in Section 4.2.2.1.

As part of the coalbed methane development, a compressor station would be constructed on an existing well pad located on NFS lands. Potential surface water impacts would be expected to be insignificant.

Well sites are planned in areas that contain intermittent and perennial streams, including areas that contain a high potential for erosion (See Section 4.1). Construction in these areas without appropriate mitigation could lead to significant erosion and sedimentation into streams and rivers. The degree of erosion is highly variable, due to various factors. Widespread overland flow may be one of the most elusive processes to observe and quantify (Kirkby 1978). The degree of soil loss will vary from well site to well site and from road-mile to road-mile. However, a direct correlation between the amount of area exposed during construction and the amount of erosion and subsequent sedimentation in streams can be assumed (Transportation Research Board (TRB) 1980). Therefore, it is expected that, due to the larger areas undergoing development, there will be a higher sediment load to rivers and streams in the absence of mitigation.

Stipulations exist on the location of well pads near springs and highwater marks of streams, lakes, etc. There are a total of nine springs listed in various sources (Figure 3-3). According to this alternative, there is a spring located within a well window in Section 28, T34N, R5W. However, areas exist within the window that are outside of the required 400-foot buffer zone for the spring. If the final location of the well is further than 400 feet from the spring, stipulations would be met.

The potential for impacts to ground water during construction would focus on the degradation of ground water during well drilling activities. CBM well development construction activities include drilling through water bearing zones of both high and low quality ground water. This activity could result in the contamination of ground water by the introduction of poor quality water, drilling fluids, and methane gas into zones having high quality ground water. Water bearing zones between impervious layers at depth may be under high pressure. When these zones are encountered during drilling, problems may arise in controlling the pressure. Poor quality water and gas may migrate up the outside casing or along bedding planes to zones of less pressure containing higher quality ground water. However, these impacts should be insignificant given the implementation of standard industry construction practices.

According to this alternative, several shallow ground water wells are located in the vicinity of the proposed coalbed methane well sites, primarily in the western half of the Study Area. Development of coalbed methane wells near these shallow ground water wells could result in a higher potential of impact to ground water. However, negative impacts to ground water quality are not expected, since stipulations contained in Appendix A, federal regulations, state regulations, and prudent practices in industry outline construction and abandonment activities which minimize any potential impacts.

Negative impacts to ground water levels in shallow ground water wells appear likely to be negligible. Since the coalbed methane wells are completed below shallow ground water, aquifers are separated by impermeable geologic unit and are not in direct hydraulic contact, with the near-surface aquifer (see Section 3.2). This source of impact is also unlikely, since only thirty percent of inplace available water is expected to be removed from the zone of influence of each producing well due to coalbed methane well development (Hoffman, personal communication, 1989).

As part of the drilling, a reserve pit would be constructed to hold and contain the excess drilling fluids and additives during drilling. The drilling fluids could potentially contaminate shallow ground water aquifers if the reserve pit were to leak. The magnitude and duration of this impact would depend on the quantity and quality of fluids released, the length of time allowed to pass before the leak is controlled, and the permeability of the soils. The impact due to a leak in the reserve pit would also depend on the reserve pit's proximity to a shallow ground water aquifer and the use of the aquifer. The potential of this occurring is low, since all reserve pits would be lined, and any leaks would be immediately reported to the BLM and FS for implementation of remediation activities to reduce the effects of a leak.

Construction of the access roads to and from the well pads could cause an increase in erosion and subsequently increase sedimentation in surface water resources. High energy streams and rivers that are crossed could be a location of greatly increased erosion and subsequent sedimentation.

The potential for ground water impacts from road, flowline, and compressor station construction activities would be low, since these activities would not directly penetrate ground water aquifers. The source of any potential impact due to road construction would be spills or leaks of fluids such as fuels and oils used in the equipment. The magnitude and duration of an impact to ground water due to spills or leaks would depend upon the amount of fluid released. Since the spills would be localized, no short- or long-term impacts to shallow ground water are likely to occur.

Operations. Once wells are completed and the control valves ("Christmas trees") are in place, the surface water impacts related to actual operations would consist of potential leakage of produced water into surrounding surface water resources. These are likely insignificant impacts since the quantity and quality of the produced water leakage would likely be small.

Potential ground water impacts from well field operation would be the migration of poor quality water and/or methane gas along the well bore to aquifers containing higher quality water due to corroded or poorly cemented well casings. Additional impacts could come from the mixing of water from different aquifers, primarily the mixing of high-quality water with water of lower quality. The potential impacts to ground water are not expected to be a significant impact since the Fruitland Formation is not hydraulically connected to surrounding formations. The following points summarize why no significant impact to ground water would occur (refer to Section 3.2.2 and Appendixes A-2 and A-3 for detailed discussion of these parts):

- The Fruitland Formation is a confined unit, compartmentalized, isolated from adjacent geologic units, and is overlain by the thick, impermeable Kirtland shale unit.

- The zone of interest within the Fruitland Formation targeted for CBM well development is at much greater depths compared to shallow ground water producing zones. The majority of coal-bed methane development is at depths in excess of 1,500 feet, whereas the deepest water wells are less than 500 feet.

- Based on observed petroleum reservoir characteristic data, the Fruitland Formation is overpressured and, therefore, is a closed system not connected to surrounding formations.

- The Fruitland Formation water is connate-type and has different water quality concentrations than shallow ground water aquifers, thus implying no direct connection between the aquifers.

- The ground water wells used for potable water sources are completed in the Animas Formation, Terrace deposits, and alluvial floodplain deposits which are not directly hydraulically connected with the Fruitland Formation.

- Current technology and regulations applied to coalbed methane development or well abandonment are such that the environment is protected by ensuring no leakage or migration occurs associated with well casings or abandoned wells.

The operation of access roads involves the transportation of personnel and equipment for maintenance and inspection purposes. The possible surface water impacts related to access road operation involve the accidental spilling of fuel, produced water from tank trucks, and spills from lubrication oils. Prudent construction and routine maintenance of the access roads would reduce the possibility of a road failure and subsequent sedimentation in stream areas.

The potential impacts to ground water from the use of access roads consist of spills and/or leaks of produced water from tank trucks hauling water for disposal, fuels, and other fluids used in the equipment. The magnitude and duration of any of these impacting ground water is low, since any spill or leak would be localized and contained. A major spill or leak from a truck transporting produced water could possibly have a slightly higher potential impact on ground water; however, the majority of trucking will take place in the eastern half of the Study Area. Fewer shallow ground water wells are located near proposed CBM wells in this section of the Study Area. Any major spill or leak must be immediately reported to the BLM and FS and remediated to lower potential impacts. Because of the controls required for reporting and cleaning up of any spills or leaks, and the depth and type of geologic material overlying shallow aquifers (Section 3.2.2), potential impacts to ground water are expected to be minimal. In addition, since development of coalbed methane gas wells and flowlines in the HD Mountains, no leaks or spills have occurred from produced water trucks on NFS lands (Bell, personal communication, 1990).

The operation of the flowlines includes the possibility of a leak from either the gas lines or the produced water lines. A leak from the gas flowline could result in an incendiary event and the possibility of fires on NFS lands. Resultant effects on surface water could include added sediment load to surface water resources from bared soils. A leak from produced water flowlines could include additional inorganic salts in surface water

resources, and resultant effects on stream and river fauna and flora. Since produced water from coalbed methane wells is a distinctive bicarbonate-type water, violations of the state water quality standards could occur. Since development of coalbed methane gas wells and flowlines in the HD Mountains, no gas or produced water leaks have occurred from flowlines on NFS lands (Bell, personal communication, 1990).

Operation of new flowlines would have impacts similar to those described under operations in Section 4.2.2.1.

Impacts to surface waters related to the operation of the compressor station at the Bull Creek Federal well location could include the accidental release of fuel and lubrication fluids from the site and the possibility of their runoff into surface water resources. Potential impacts to ground water from the operation of the compressor station include the accidental spilling or leakage of lubrication liquids and their migration into shallow ground water. The magnitude and duration of this impact is low, since the spill or leak would be minor and localized. The potential impact to ground water from the continued operation of the compressor station is expected to be minimal.

Abandonment. Minimal construction efforts are required for the abandonment of the wells. If successful erosion mitigation measures are pursued, the process of abandonment of well facilities are not expected to have a significant impact on surface water resources.

Potential impacts to ground water due to well abandonment would be similar to those impacts associated with well operation. Improper abandonment and/or corroded well casing could allow methane gas or poor quality water to migrate and mix with higher-quality water. Also, methane gas could migrate along the well casing to shallow ground water wells or to the surface. This impact should not occur, since wells to be abandoned would be completely cemented to prevent impacts to ground water. Abandonment could potentially result in high impact to ground water if wells were improperly abandoned, especially in the western half of the Study Area. However, with BLM approved abandonment procedures, impacts to ground water are not expected to occur.

4.2.2.3 Alternative C - Current Direction

Under this alternative, there would be a total of 95 wells affecting approximately 285 acres of NFS lands. Additionally, an approximate total of 52 miles of roads/flowlines would be built on NFS lands affecting an approximate area of 315 acres. This is approximately a 250 percent increase in land disturbance over

Alternative B, and almost a 700 percent increase over Alternative A. There would also be approximately 37 additional stream crossings for this alternative.

Construction. Impacts to surface water are erosion and subsequent sedimentation to streams and rivers. The extent of impact would depend on slope, aspect, and grade. A minor increase of runoff due to the addition of an impervious surface may also occur. Other impacts related to well construction are the use of fuels, lubricants, and solvents, which could wash off the well pad during rainfall events. Strict control of inputs into reserve pits would be necessary to avoid any RCRA classifications of liquids in the pits.

Well sites may be located in areas that contain intermittent and perennial streams, including areas that contain a high potential for erosion (see Section 4.1). The construction in these areas could lead to significant erosion and sedimentation into streams and rivers. Mitigation measures are necessary to control the potential degradation in water quality. The addition of interception ditches, vegetative filters, and temporary settling ponds; the minimizing of construction time; and water quality monitoring are examples of measures that may be necessary.

The potential for impacts to ground water during construction activities would be similar to those discussed in Section 4.2.2.2. Under Alternative C, additional shallow ground water wells could potentially be impacted during coalbed methane development. Areas with increased risk of impact are primarily located in the north central portion of the Study Area (Beaver Creek, Hayden Creek, and Lange Canyon areas). Additional potential high risk areas extend to the east along Squaw Creek. The source of potential impact to ground water and the magnitude and duration of those impacts would be similar to those discussed in Section 4.2.2.2.

Given the higher amount of land disturbed, one can assume that the amount of erosion and subsequent sedimentation will also be higher. However, it is difficult to quantify, given the varying topography and soil types in the area (see Section 4.1 for acreage estimates).

Operations. The potential impacts on ground water from well field operations would be similar to those discussed in Section 4.2.2.2. An increase in potential negative impacts could possibly occur due to the increased number of flowlines in the western half of the Study Area and the increased number of produced water hauling trips required in the eastern half of the Study Area. However, the flowlines will be constantly monitored for leakage and the increase in potential impacts would only be due to the large increase in number of flowlines required. Also, any spills or leakage from produced water hauling trucks would be reported and

remediated; the increase in potential impacts would only be due to the large increase in the number of produced water hauling trips required.

Abandonment. Minimal construction efforts are required for the abandonment of CBM wells. The process of abandonment of well facilities is not expected to have a significant impact on surface water resources. Potential impacts to ground water due to abandonment would be similar to those impacts discussed in Section 4.2.2.2.

4.2.3 Impacts Summary

Potential impacts to water resources can be divided into two areas: Surface and Ground Water Resources. The potential impacts to Surface Water Resources include the degradation of water quality below state water quality numerical standards, degradation of water quality beyond minimal considerations necessary to maintain the appropriate state classification/designation, and the changing of channel morphology to produce undesirable effects such as aggradation, degradation, or side cuttings. The potential impacts to ground water resources would be the degradation in quality of potable ground water, and the increase or decrease in ground water levels during construction, operation, or abandonment activities.

Under Alternative A, a total of 46 acres would be disturbed by 19 miles of flowline/road construction on NFS lands. Eight stream crossings are proposed. Impacts to surface water resources could occur if there was considerable erosion and subsequent sedimentation during construction, and leakage of produced water into drainage ways from flowlines, tanks, or tanker truck accidents. Impacts to shallow ground water could potentially occur due to surface spills or flowline leaks.

Under Alternatives B and C, impacts to surface water resources would vary as a result of the number of stream crossings and the erosion occurring as a result of construction near drainageways. Impacts are possible from the accidental release of produced water into drainageways, the release of materials in reserve pits, and the release of fluids, solvents, and fuels from support activities. Shallow ground water quality could be affected during construction, operation, and abandonment activities by surface spills or poor well construction activities.

The potential for negative impacts is greater under Alternative C. With a total of 646 acres of disturbance on NFS lands and a total of 55 stream crossings, the potential of sedimentation into drainageways is much larger than the two other alternatives. The potential for changes in ground water could also increase. However, impacts to ground water in reality should be negligible since CBM wells completed in the Fruitland Formation

are separated from shallow aquifers (Animas Formation) by the impermeable Kirkland Shale. In addition, with the use of current technology and methods for CBM well development and abandonment, no leaks or migration of contaminants is anticipated. Only approximately one-third of the available in-place Fruitland water, in the vicinity of the well, would be removed during the life of CBM well production (Jones et al. 1988). The rate of water production should decrease rapidly for the first few years then stabilize to relatively low levels during the life of a well (Clark and Hemler 1988; Decker et al. 1988).

4.2.4 Cumulative Impacts

Coalbed methane production wells, flowlines, and injection wells are presently operating within the Study Area. The operation of these activities has not adversely impacted surface or ground water quality or shallow ground water levels (see Sections 3.2 and 4.2.2.1). If the required stipulations, regulations, standard engineering practices, and appropriate mitigation measures are followed, additional CBM well-field development activities should not result in long-term cumulative impacts to ground or surface waters. This includes no expected impacts on surface springs/seeps.

4.2.5 Mitigation Summary

In addition to the standard procedure and stipulations (Appendix A) discussed in the beginning of this section, the following mitigation measures should be implemented in response to the expected impacts.

- Construction near perennial or ephemeral drainageways should contain either: vegetation buffers, or temporary settling ponds, at the construction site to contain any erosion and prevent the movement of soils into the drainageways.

- Bradenhead testing should be conducted pursuant to BLM Conditions of Approval (Appendix A-2).

- Construction time should be minimized to reduce the possibility of erosion and sedimentation.

- Construction across a stream should incorporate prudent design, including riprap with sufficient capacity to manage high energy flow associated with thunderstorms and spring runoff.

- Design and implementation of a surface and ground monitoring network, and the development of a spill contingency and response plan (containment, cleanup, and mitigation of losses) should be formulated.

- Access roads should be maintained as required.

- Produced water fluid transfer to or from water trucks should occur at well pads or FS approved locations.

4.2.6 Unavoidable Adverse Impacts

Unavoidable adverse impacts to water resources would include limited short-term increases in stream sediment loads during and immediately following construction, until revegetation and constructed erosion control features effectively reduce erosion to area levels.

4.3 AIR QUALITY

4.3.1 Introduction

Air quality of the Study Area could be impacted as a result of project construction and operation in the following ways: 1) suspended particulate matter (dust) generated from the road, drill site, compressor site, and well construction activities; 2) gaseous emissions from the operation of the compressor and pump stations; and 3) gaseous particulate emissions from construction machinery.

Impacts could be considered significant if the emission of pollutants from any activities associated with the construction and operation of the proposed project exceed the concentration threshold values set by the Prevention of Significant Deterioration (PSD) and the state and federal ambient air quality standards. These concentration threshold values were developed to protect public health and welfare.

Air quality impacts from the operations of the coalbed methane wells and the compressor stations were evaluated for each alternative using dispersion modeling. These models utilize as input the emission rates of each pollutant, usually supplied by the equipment manufacturers, the location of each source, and representative meteorological data. Using this information, the model provides the magnitude and location of the ambient impacts from each pollutant.

The USEPA Industrial Source Complex (ISC) Model was used (EPA 1987). The ISC model is designed to assess ground-level pollutant concentrations from a wide variety of sources associated within an industrial complex.

Several assumptions were made in developing the input data for the model (see EIS files). These assumptions were made because there is a lack of source-specific and site specific meteorological data; however, the assumptions employed were considered to be conservative and would result in the over-estimation of impacts from implementation of an alternative. The assumptions included low wind speed, directionally persistent winds with stable atmospheric conditions, and flat terrain throughout the Study Area.

4.3.2 Direct and Indirect Impacts

4.3.2.1 Alternative A - No Action

Construction. The air quality impacts generated during construction of flowlines to connect drilled wells would include suspended particulate matter (dust) and gaseous pollutants. The major sources of these pollutants are expected to be construction vehicles and equipment. Local impacts from these construction activities would be highly variable, as impacts are a function of existing site-specific meteorological conditions and source/receptor relationships. Locally elevated pollutant levels may exist during these types of construction activities. However, they are temporary and transient in nature.

Operations. During the operational phase of this alternative, gas and water flowline connections to the existing wells would be completed. Water produced by the completed wells will be transported by collection system pipelines and by water truck to disposal well facilities. Dust generated by the water transport will be localized and variable. Air quality impacts resulting from normal operation of these flowlines would be nominal.

Abandonment. Air quality impacts associated with abandonment activities under this alternative are expected to be nominal, and temporary and transient in nature.

4.3.2.2 Alternative B - Proposed Action

Alternative B involves the construction and operation of 34 coalbed methane wells in the Study Area and one compressor station at the Bull Creek site on NFS lands (Table 2-1, Figure 2-2). The development of the wells

would include new construction of 27.5 miles of combined access road and flowlines ROW, and well pads approximately three acres in size, each. For purpose of this analysis, all construction would occur in one year.

Construction. During the construction phase of this alternative, fugitive dust would be generated by land clearing for access roads, facility pads, flowline construction, and vehicle traffic. Gaseous pollutants, including oxides of nitrogen (assumed to be NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), hydrocarbons (HC), and aldehydes would also be emitted during project construction (EPA 1985). The major sources of these pollutants are expected to be construction vehicles and equipment. There will be minimal flaring of gas at the well sites during completion and/or well connection to flowlines. Amoco anticipates flaring to occur at each well for intermittent periods during daylight hours. Depending on the well location, these flaring activities should last on the order of one day to four weeks (Brown, personal communication, 1990). Since the flaring activities are intermittent and temporary in nature, the air quality impacts due to flaring are also expected to be intermittent and temporary. Local impacts from these construction and operation activities would be highly variable, as impacts are a function of existing site-specific meteorological conditions and source/receptor relationships. Locally elevated pollutant levels may exist during these types of construction and operation activities. However, they are temporary and transient in nature.

Operations. During the operations phase of this alternative, air quality impacts may result from the emission of gaseous pollutants (NO_2, CO, HC, and SO_2) from natural gas-fired gas compressors and well dewatering pumps. Refer to Table 4-4 for a summary of impacts resulting from the operations phase of this alternative. Annual NO_x impacts for this alternative estimated by the ISC model were 0.79 $\mu g/m^3$. One-hour and eight-hour CO concentrations were estimated at 6.51 $\mu g/m^3$ and 4.56 $\mu g/m^3$, respectively. One-hour hydrocarbon (HC) concentrations were 3.14 $\mu g/m^3$. Three-hour, twenty-four-hour, and annual SO_2 concentrations were estimated at 1.99 $\mu g/m^3$, 0.88 $\mu g/m^3$, and 0.22 $\mu g/m^3$, respectively. Maximum concentrations estimated by the ISC model are well below applicable air quality standards.

Abandonment. Air quality impacts associated with abandonment activities under this alternative are expected to be nominal and temporary and transient.

4.3.2.3 Alternative C - Current Direction

The current direction alternative involves the construction and operation of 116 coalbed methane gas wells in the Study Area and two compressor stations located in the southern part of the Study Area (Figure 2-7). In addition, one compressor station will include a gas dehydration unit, one glycol regenerator, and the possibility

of an amine generator to remove any CO_2 in the gas. Development of the gas wells would include the construction of 73 miles of combined access roads and flowlines ROW, and 25.5 miles of flowlines ROW connecting to well pads of approximately three acres in size, each.

Construction. During the construction phase of this alternative, fugitive dust would be generated by land clearing for access roads, facility pads, flowline construction, and vehicle traffic. Gaseous pollutants, including oxides of nitrogen (assumed to be NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), hydrocarbons (HC), and aldehydes would also be emitted during project construction (EPA 1985). The major sources of these pollutants are expected to be construction vehicles and equipment. Local impacts from these construction and operation activities would be highly variable, as impacts are a function of existing site-specific meteorological conditions and source/receptor relationships. Locally elevated pollutant levels may exist during these types of construction and operation activities. However, they are temporary and transient in nature.

Operation. During the operations phase of this alternative, air quality impacts may result from the emission of gaseous pollutants (NO_2, CO, HC and SO_2) from natural gas-fired gas compressors and well de-watering pumps. Smaller quantities of gaseous pollutants would also be generated by the operation of various internal combustion sources such as tank heaters, an amine system, and gas dehydrators at one of the compressor stations. Refer to Table 4-4 for a summary of impacts resulting from the operations phase of this alternative. Maximum concentrations estimated by the ISC model are well below applicable air quality standards.

Abandonment. Air quality impacts associated with the abandonment activities under this alternative are expected to be nominal, and temporary and transient in nature.

4.3.3 Impacts Summary

A summary of emissions in the operations phase from the compressor and well facilities for each alternative is presented in Table 4-4. The emissions are well below the federal and state air quality standards.

TABLE 4-4

IMPACTS TO AIR QUALITY AS ATMOSPHERIC CONCENTRATION FROM PROPOSED OPERATIONS UNDER ALTERNATIVES B AND C[1]

Pollutant Emissions Interval	Alternative B ($\mu g/m^3$)	Alternative C ($\mu g/m^3$)	Colorado and Federal Standards ($\mu g/m^3$)
Nitrogen Dioxide			
Annual	0.79	3.20	100
Carbon Monoxide			
1-hr	6.51	6.57	40,000
8-hr	4.56	4.60	10,000
Hydrocarbons			
1-hr	3.14	12.85	235[2]
Sulfur Dioxide			
3-hr	1.99	3.72	1,300
24-hr	0.88	1.65	365
Annual	0.22	0.41	80

1 No new point source of emissions (compressor station) is proposed under Alternative A; construction emissions are not included

2 Ozone standard

Maximum impacts estimated at the nearest border of the Weminuche Wilderness are presented in Table 4-5. Impacts of sulfur dioxide (SO_2) are well below the SO_2 increment values of 2 $\mu g/m^3$ set forth for PSD Class I areas. There are currently no increment values for carbon monoxide (CO) or non-methane hydrocarbons (HC). The oxides of nitrogen impact for Alternative C is 2.16 $\mu g/m^3$ which is below the NO_x PSD increment of 2.5 $\mu g/m^3$. In view of these low concentrations at the Weminuche Wilderness border, there should be no noticeable effect on the visibility in the wilderness area.

Uranium has been reported in the Fruitland Formation at one location approximately 50 miles southwest of the Study Area (Fassett & Hinds 1971). Radon is often associated with radioactive deposits and may be present locally in the Fruitland. In southwest Colorado, radioactive ores are generally associated with Jurassic age deposits which are much deeper than the coalbed methane producing zones of the Cretaceous Fruitland Formation. Therefore, the probability of releasing radon gas is low. Furthermore, should radon gas be detected at one location, this does not indicate that it will be detected in adjacent areas (Lammering, personal communication, 1990). Any radon gas tapped by a CBM well would be contained within the closed CBM gas production system; however, should radon gas be released into the atmosphere at a well site, it would likely be a very small quantity and would be quickly dispersed, posing minimal health or environmental risk since exposure to higher levels of radon gas in areas of Colorado is related to confined or closed spaces (i.e., basements).

4.3.4 <u>Cumulative Impacts</u>

The maximum ambient levels of each modeled pollutant resulting from the simultaneous operation of all the facilities discussed above in each alternative, in combination with the existing ambient pollutant levels for the City of Durango, are presented in Table 4-6. Data from the City of Durango was used because it is the closest available monitoring location to the Study Area. The Durango data can be considered representative of worst case background conditions at the Study Area. These levels do not exceed the Colorado Ambient Air Quality Standards.

4.3.5 <u>Mitigation Summary</u>

- Comply with all applicable federal and state regulatory requirements concerning permitting of appropriate project facilities.

TABLE 4-5

MAXIMUM AIR QUALITY IMPACTS AT
THE WEMINUCHE WILDERNESS BOUNDARY

Pollutant	Gas Field Development Maximum Annual Average Impacts ($\mu g/m^3$) Alternative B	Alternative C	PSD Class I Annual Average Increments ($\mu g/m^3$)
Total Suspended Particulates	--	--	5
Sulfur Dioxide	0.14	0.32	2
Oxides of Nitrogen	0.57	2.16	2.5
Carbon Monoxide	0.39	0.72	--
Hydrocarbons	0.23	0.87	--

TABLE 4-6

CUMULATIVE AIR QUALITY IMPACTS AS ATMOSPHERIC CONCENTRATION ($\mu g/m^3$)[1]

Pollutant Emissions Interval	Alternative A			Alternative B			Alternative C			Colorado and Federal Standards ($\mu g/m^3$)
	Project[2]	City of Durango[3]	Total	Project	City of Durango	Total	Project	City of Durango	Total	
Nitrogen Dioxide Annual	--	3.76	3.76	0.79	3.76	4.55	3.20	3.76	6.96	100
Carbon Monoxide										
1-hr	--	2,300	2,300	6.51	2,300	2306.51	6.57	2,300	2306.57	40,000
8-hr	--	2,300	2,300	4.56	2,300	2304.56	4.60	2,300	2304.60	10,000
Hydrocarbons										
1-hr	--	98	98	3.14	98	101.14	12.85	98	110.85	235[4]
Sulfur Dioxide										
3-hr	--	26.2	26.2	1.99	26.2	28.19	3.72	26.2	29.92	1,300
24-hr	--	26.2	26.2	0.88	26.2	27.08	1.65	26.2	27.85	365
Annual	--	13.1	13.1	0.22	13.1	13.39	0.41	13.1	13.51	80

1 Construction impacts are not included
2 No new point source of emissions is proposed under Alternative A
3 "Source of Durango Info". Colorado Air Quality Control Commission 1987
4 Ozone standard

- Follow manufacturers' specifications for the operation and maintenance of all facilities and vehicles at project facilities and project-related vehicles to reduce emissions.

- Operate all facilities and vehicles to achieve the highest possible fuel efficiency and reduce emissions.

- Water construction areas and roads to the maximum extent practicable to reduce the generation of fugitive dust.

4.3.6 Unavoidable Adverse Impacts

No unavoidable adverse impacts to air quality are expected to result from project construction and operation in either short-term or long-term time frames.

4.4 VEGETATION, TIMBER, AND GRAZING

4.4.1 Introduction

Gas field development could result in a number of types of impacts to natural vegetation and to timber and grazing resources:

- Disturbance or loss of vegetation would occur from drill pad construction, road construction, and other earth-moving activities. The effects may be short- or long-term, depending on the plant community affected and the success of natural or artificial revegetation. Lack of revegetation success could have adverse impacts on pre-existing land uses, including grazing, wildlife habitat, or recreation.

- Wetland and riparian areas could be adversely impacted directly through construction, or indirectly through changes in surface or ground water resources. Wetlands are protected under Executive Orders 11990 and 11988, Forest Service Manual direction (2527), and the National Forest Management Act of 1976 to minimize their destruction, loss, and degradation. They are defined by federal regulations as areas with characteristic wetland (hydrophytic) vegetation, saturated (hydric) soils, and wetland hydrology. Riparian vegetation is more broadly defined and includes streamside trees, shrubs, and herbaceous plants. Riparian areas are considered sensitive but are

not subject to specific federal regulations. Both types of areas are important for wildlife and biotic diversity, and have other functional values.

- Two rare or sensitive plant species occur within the Study Area (lower Spring Creek and northeast portion of Study Area), and could potentially be affected by construction activities.

- Construction and increased human activity could potentially have indirect effects on vegetation, such as introduction of undesirable and noxious weeds, and increase in fires. Herbicide use could damage natural vegetation. Accidental releases of fuels, lubricants, or other materials during construction or operation could affect upland, riparian, or wetland vegetation.

- Effects on timber resources could include loss of future timber production and negation of prior timber stand improvements in forested areas used for well pads, access roads, or flowlines. Construction of new roads near or through forest stands with commercially valuable timber could be a beneficial indirect impact if the stands could be better managed for timber production.

- Grazing could be adversely affected by loss of forage on areas disturbed during construction or occupied by facilities during operation. Range improvements such as fencing and stock ponds could also be adversely impacted. Impacts to range improvements could affect separation or movement of livestock, stock watering, and other grazing operations.

Standard mitigations (Appendixes A-1 through A-4) required by the FS and BLM would generally eliminate or reduce impacts to acceptable levels. Mitigation measures include revegetation of disturbed areas with approved seed mixes, fertilizer, and mulch (on steeper terrain); use of erosion-control devices where appropriate; control of noxious weeds on disturbed areas; prevention of fires by restrictions on burning and by use of mufflers or spark arresters on all vehicles; protection and restoration of existing range improvements; safe handling and storage of fuels, lubricants, and other liquids and materials to prevent soil and water contamination; salvage of cut timber; and restrictions on use of herbicides.

Of the various types of impacts, losses of wetland and riparian vegetation are considered most sensitive. The location of wetland and riparian areas were used as one factor in determining the proposed locations of access road and flowline corridors. The distribution of wetland and riparian areas is shown on Figure 3-7. This map shows wetlands, which largely consist of marshes and wet meadows in the larger valleys; riparian areas, including cottonwood woodland and shrub communities along major and minor drainages; and areas

representing a mixture of both. As displayed on Figure 3-7, the width of riparian and wetland/riparian areas along minor drainages is exaggerated for readability.

4.4.2 Direct and Indirect Impacts

4.4.2.1 Alternative A - No Action.

Construction. Alternative A would involve construction of 19 miles of flowlines on NFS lands and 6.5 miles of flowlines on private lands within the Study Area. For evaluation of impacts, it was assumed that construction would involve removal or severe disturbance of all vegetation within the 20-foot-wide construction ROW. A total of about 46 acres of vegetation on NFS lands and 16 acres on private lands would be affected. The most common vegetation types on NFS lands would include ponderosa pine (36 percent), pinon-juniper (19 percent), Gambel oak (18 percent), sagebrush (12 percent), and cottonwood woodland (6 percent). The most common type within the flowline ROW on private lands are cottonwood woodland (59 percent) and agricultural land (13 percent).

The construction ROW would be revegetated with a mixture of grass species to help stabilize the soil and return the area to pre-existing vegetative cover. The vegetation types present in the Study Area generally have a fair to good revegetation potential. Following revegetation, the ROW would gradually recover to original conditions through the process of secondary succession. The time required to return original vegetation composition and structure would vary depending on plant community. Times would vary from 1 to 2 years in cropland, to 100 to 150 years in areas where mature trees were removed. The grass species used in revegetation would eventually be eliminated in shrub and forest vegetation, but may persist indefinitely in grasslands and other open habitats.

The flowline ROWs would cross or parallel riparian areas at three locations and would parallel creeks in riparian areas for about six miles. They would also cross wetland/riparian at two locations and would be located in wetland/riparian area for about 3.5 miles (Figures 2-1 and 3-7). Riparian and wetland areas are considered sensitive areas due to their limited occurrence in the Study Area, their importance as habitat for numerous wildlife species, and other functional tools. Construction activities within the riparian and wetland areas are regulated by Federal law and Executive Orders (for wetlands) and FS policies (for riparian areas). The direct effects of construction would be similar to those in other upland vegetation areas - removal of existing vegetation. Long-term effects could potentially occur in wetlands if construction alters surface or ground water amounts or movement on a micro- or macroscale. Assuming restoration of original ground surface and

hydrological conditions, natural recovery of wetland and riparian areas should be fairly rapid, due to the favorable growing conditions present in these areas.

In the absence of mitigation, and based on the wetlands/riparian map (Figure 3-7), flowline construction would affect about 7.2 acres of riparian, and 0.7 acres of wetland/riparian vegetation, for a total of 7.9 acres of high-sensitivity vegetation on NFS lands, and 5.5 acres of riparian and 0.4 acres of wetland/riparian vegetation on private lands (Figure 4-4). The actual impacts would be less, since the FS will insist that the flowlines routes be sited to minimize impacts to the relatively narrow wetland and riparian areas. These mitigations would reduce the direct impact to riparian and wetland vegetation to about 0.2 acres. Most of the impacts to riparian vegetation on private lands are probably unavoidable (affecting cottonwood woodland on the floodplain of the Piedra River).

Two rare or sensitive plant species occur within the Study Area, and could potentially occur within the flowlines construction ROW. In the absence of mitigation, construction might eliminate small populations and individuals or reduce the size of larger populations. Botanical surveys prior to construction will identify whether sensitive plant species are present on affected NFS lands, and whether minor route realignments or other mitigations should be required.

Flowline construction could have a number of indirect impacts on vegetation, including introduction of undesirable and noxious weeds, increase in fires, accidental releases of fuels, lubricants, or other materials, and fugitive dust. Standard FS permit stipulations would require control of weeds, prevention of accidental fires, and prevention of the accidental release of fuels or other materials.

The flowline ROWs would cross portions of the Sauls Creek and HD range allotments. Minor reductions in forage availability would occur during and following construction, and would be mitigated by revegetation of the disturbed area. Any range improvements damaged during construction would be repaired.

About two miles of flowlines ROW would also cross ponderosa pine stands that are suitable for commercial timber production. Trees within the ROW would be cut during construction, and would be sold by the FS. Flowline ROWs would be located to minimize removal of all tree species.

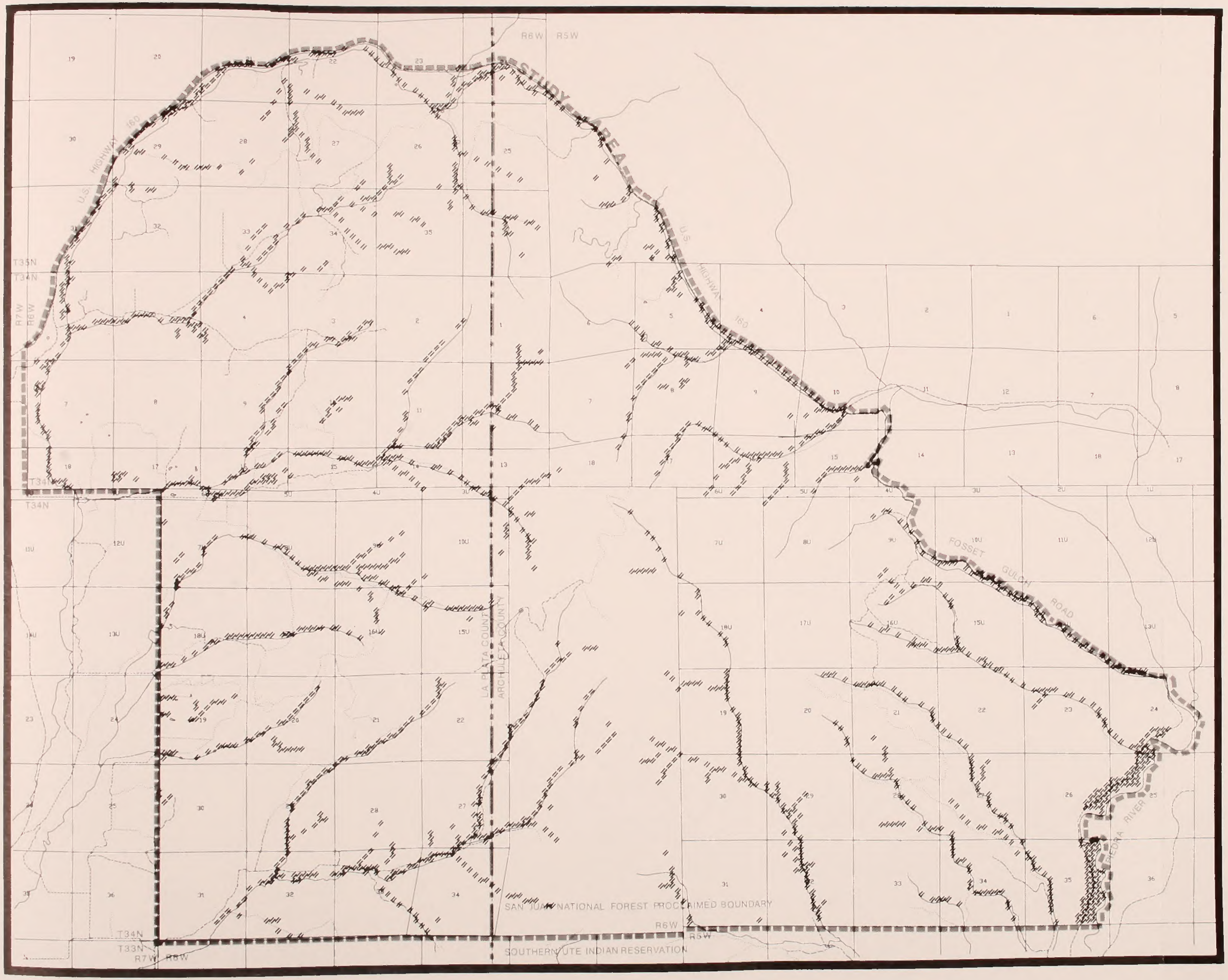
Operations. Flowline operations may cause a minor disturbance to vegetation during routine or emergency maintenance procedures.

Existing wells, access roads, flowlines, and water disposal wells occupy about 343 acres within the 56,910-acre Study Area. These areas are essentially not vegetated at present and would continue in that state until completion of operations. Current well field activities have little or no impact on the surrounding natural vegetation. Removal of water from deep aquifers from existing coalbed methane gas wells is unlikely to have any effects on wetland or riparian vegetation, which depend on surface flow or shallow aquifers. Operation of the two existing water disposal wells would also have little or no impact on vegetation.

Abandonment. Following completion of production operations, the well field and ancillary facilities would be abandoned. Well pads would be removed and the areas revegetated. Roads would be removed and revegetated, or retained, based on the management goals and requirements of the FS. Abandonment of flowlines would have no effect on vegetation, since the buried flowlines would simply be left in place. The revegetated roads and well pads would initially have a vegetation composition based on the species used in the seed mix. To be considered revegetated, the disturbed areas must have a ground cover of suitable grass and forb species and be free of noxious weeds. Natural succession would gradually return these areas to a composition and structure similar to the surrounding vegetation.

4.4.2.2 Alternative B - Proposed Action

Construction. The 28 wells to be located on NFS lands would require removal of 84 acres of natural vegetation for construction of the well pads. Although the exact locations are not known (except for five wells in the Sauls Creek drainage), the windows within which the wells would be placed are about 53 percent pinon-juniper, 28 percent ponderosa pine, 10 percent Gambel oak scrub, and 7 percent sagebrush. An additional six wells on private lands would affect about 18 acres of natural vegetation, including ponderosa pine, pinon-juniper, sagebrush, mixed conifer, and cottonwood woodland. Assuming that the wells are successful, approximately two of the three acres at each well site would remain unvegetated for the operating life of the well field. About one acre at each well site would be revegetated after construction, and would undergo natural succession as described in Section 4.4.2.1. The total acreage of direct but temporary impacts would be about 28 acres on NFS lands and six acres on private lands, and the acreage of direct long-term impact would be 56 acres on NFS lands and 12 acres on private lands. Indirect impacts to vegetation would also be similar to that for construction of pipelines under Alternative A (Section 4.4.2.1).



WETLANDS/RIPARIAN SENSITIVITY

HIGH SENSITIVITY AREA INCLUDES AREAS OF WETLANDS, RIPARIAN AREAS, AND WETLANDS/RIPARIAN AREAS

// AREA OF HIGH SENSITIVITY

NOTE: AREAS ARE OVER EXAGGERATED FOR CLARITY.

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 4-4

None of the five known well locations in the Sauls Creek drainage are located in wetlands or riparian areas (Figures 2-2 and 3-7). Eight of the well windows on NFS lands contain riparian areas along intermittent creeks. The remaining 15 well windows are entirely within upland areas. In the absence of mitigation, construction of the wells could affect 16 acres of riparian area permanently and eight additional acres temporarily. However, direct losses of wetland and riparian vegetation due to well pad construction are expected to be minor. The riparian areas occupy a relatively small portion of the area within each well window (about 5 to 6 percent overall); an average of about 37.5 acres within each 40-acre window is available to site a 3-acre well pad. In addition, the FS insists that well pads be located outside wetland or riparian areas, if possible. On private lands, two well windows are located primarily within riparian (cottonwood woodland) vegetation on the floodplain of the Piedra River, and may require the removal of 3 to 6 acres of riparian woodland. One well window on private lands includes a small amount of riparian vegetation, while the remaining three are entirely in upland areas.

In addition to direct losses, riparian and wetland vegetation could potentially be affected by downhill movement of soil eroded from the well pads. Impacts are expected to be minor, since the FS requires that adequate erosion control be used during construction (Appendix A-4).

Fifteen of the well windows on NFS lands are located within grazing allotments, including five in Sauls Creek and ten in the HD allotment. The areas which may be primarily affected include secondary range and some non-range. Construction of the well pads would eliminate livestock forage within these areas for the life of the project. Impacts on overall forage availability within the allotments will be insignificant, since these allotments include more than 11,000 acres of suitable range. Impacts on livestock forage availability on private lands will also be minor. Fenced well pad locations can interrupt the traditional movement of livestock within a pasture by creating barriers. A relatively unlikely, but possible, impact is the contact of livestock with toxic substances associated with gas production.

Eleven of the 21 well windows on NFS lands are partially or entirely located in forest stands suitable for commercial timber production. Up to 33 acres of commercial timber land might be affected, out of 9,000 acres suitable for commercial timber production within the Study Area. Commercially marketable timber removed during construction would be sold by the FS. Where possible, ROWs will be located to minimize the removal of trees.

Construction of access roads and flowlines would involve removal of most vegetation for a ROW 50 feet-wide . The road bed would permanently occupy approximately 20 feet, and the remaining 30 feet would be

revegetated. The total area affected would be 141 acres on NFS lands, and 27 acres on private lands, of which 67 acres would be permanent losses for the road. The 50-foot wide transportation ROW system on NFS lands includes about 49 percent pinon-juniper, 35 percent ponderosa pine, 6 percent Gambel oak, 6 percent sagebrush, and small amounts of grassland and mixed conifers. Where possible, ROWs will be located to minimize the removal of trees. The actual ROW location could potentially be moved from the proposed position up to 275 feet to either side of the centerline within the 600-foot transportation corridor, based on construction requirements and resource sensitivities. The distribution of impacts among the various vegetation types would probably be about the same if the ROW location is changed, since the relative proportion of the vegetation types across the 600-foot wide corridor is virtually consistent. The small acreage of access road corridors on private lands would be located primarily in ponderosa pine and mixed conifer.

The proposed ROW system would cross riparian areas along creeks at about 12 locations, and would parallel creeks in or immediately adjacent to riparian areas for about three miles. No wetland or wetland/riparian area would be affected. In the absence of mitigation, the total area of riparian vegetation potentially disturbed within the ROW would be about 15.5 acres on NFS lands (or about 11 percent of the ROW), and none on private lands. FS mitigation measures will insist that roads cross riparian areas at right angles, if possible, and that roads parallelling a stream be located outside the riparian areas, if possible. This mitigation would reduce temporary direct impacts to riparian vegetation to about 0.7 acres and permanent direct impacts to an additional 0.5 acres. Except at stream crossings, riparian vegetation can generally be avoided by relocating the ROW within the 600-foot wide transportation corridor, since the transportation corridor is only about 9 percent riparian.

About seven miles of transportation ROW would be located on primary or secondary range in grazing allotments, and would result in temporary loss of about 25 acres of forage, and permanent losses of an additional 15 acres. About 7 miles of the transportation ROW would have a permanent or long-term effect on about 40 acres of potential timber production areas on NFS lands. Another potential impact to range management is the removal of vegetation that was an obstacle to the passage of livestock, thereby interrupting the pasture management system.

The impacts of construction of the flowlines within the transportation ROWs are covered above. However, the 20-foot width required for flowline construction would be revegetated following construction, as described under flowline construction for Alternative A (Section 4.4.2.1.). In addition, Alternative B would include the 19 miles and 6.5 miles of currently planned flowline construction on NFS lands and private lands, respectively, described under Alternative A.

One new compressor station would be required, and would be sited on NFS lands in the southeast quarter of the Study Area. This compressor station would be sited on the existing Bull Creek well pad, so that no additional direct disturbance of vegetation would occur for construction. Minor indirect impacts such as those discussed above for flowline construction in Alternative A may occur during construction.

Operations. The well pads would remain unvegetated until completion of operations. Well field activities would have little or no impact on surrounding natural vegetation. Removal of produced water from deep aquifers is unlikely to have any effect on wetland or riparian areas.

Access roads would remain unvegetated for the life of the project. No additional impacts to vegetation are expected.

Flowline operations may result in a minor disturbance to vegetation during routine or emergency maintenance procedures.

The compressor stations would be equipped with clean-burn control technology, and emissions are unlikely to have any effects on vegetation. Deep well disposal of produced water would have no effect on vegetation.

Abandonment. The effects of abandonment would be the same as those discussed for Alternative A (Section 4.4.2.1).

4.4.2.3 Alternative C - Current Direction

Construction. A total of 285 acres of natural vegetation would be removed on NFS lands for the new well pads. Although the exact locations are not known (except for the five wells in Sauls Creek), the windows within which the wells would be placed are about 33 percent ponderosa pine, 30 percent pinon-juniper, 24 percent Gambel oak, 17 percent mixed conifer, and small amounts of sagebrush, grassland barren, and cottonwood woodland (Figures 2-7 and 3-7). The 21 wells (63 acres) on private and state lands would be located in windows containing ponderosa pine, cropland, mixed conifer, pinon juniper, cottonwood woodland, sagebrush, and small amounts of other types.

Assuming that the wells are successful, about two acres at each well site would be used during operation and the remaining acre would be revegetated after construction. The area of direct temporary impacts would be 95 acres on NFS lands and 21 acres on private and state lands, and the area of direct long-term impacts would

be 190 acres on NFS lands and 42 acres on private and state lands. Indirect impacts to vegetation would also be similar to that for construction of pipelines under Alternative A (Section 4.4.2.1.).

None of the five known well locations on Sauls Creek are located in wetlands or riparian areas. Nine of the well windows on NFS lands contain wetland/riparian areas, and 33 contain riparian areas along intermittent creeks. The remaining 48 well windows are entirely within upland areas. In the absence of mitigation, construction of the well pads might potentially affect up to 27 acres of wetland/riparian areas, and up to 99 acres of riparian vegetation. However, because the FS insists that well pads be located outside wetland or riparian areas, if possible, direct losses of wetland and riparian vegetation due to well pad construction are expected to be minor. The wetland and/or riparian areas generally occupy a relatively small portion of the area within each well window. On private lands, several well windows are primarily located within riparian woodland on the floodplain of the Piedra River. Most of the well windows on private or state lands include riparian or wetland/riparian areas along streams, and four are entirely in upland areas.

Fifty-six of the well windows on NFS lands are located within grazing allotments, including 16 in Sauls Creek, 30 in the HD allotment, and 10 in the Turkey allotment. The areas that may be primarily affected include mostly secondary range and non-range. Construction of the well pads would eliminate livestock forage within these areas for the life of the project. Impacts on overall forage availability within the allotments would be minor, since these allotments have more than 11,000 acres of suitable range. Impacts on livestock forage availability on private lands would also be minor.

Thirty-two of the 95 well windows on NFS lands are partially or entirely in forest stands suitable for commercial timber production. Up to 96 acres of commercial timber land might be affected, out of 9,000 acres suitable for commercial timber production within the HD Mountains Study Area. Commercial timber removed during construction would be sold by the FS.

Construction of access roads and flowlines for Alternative C would affect vegetation as described for Alternative B (Section 4.4.2.2) On NFS lands, this alternative would involve construction of about 52 miles of transportation corridor, of which 23 miles would be the same as in Alternative B. The total area affected would be 315 acres on NFS lands and 124 acres on private and state lands. About 126 acres on NFS lands and 50 acres on private and state lands would be permanently occupied by the access roads. The 50-foot wide transportation ROW on NFS lands includes about 36 percent ponderosa pine, 28 percent pinon-juniper, 24 percent Gambel oak, 6 percent mixed conifer, 4 percent sagebrush, and small amounts of grassland. Where possible, ROWs will be located to minimize the removal of trees. The actual ROW location could potentially

be moved from the proposed position up to 275 feet to either side of the centerline within a 600-foot wide transportation corridor, based on construction requirements and resource sensitivities. The distribution of impacts among the various vegetation types would probably be about the same if the ROW is changed, since the relative proportion of the vegetation types across the 600-foot corridor is virtually consistent. The small acreage of access road corridors on private and state lands would be located primarily in ponderosa pine and mixed conifer.

The proposed ROW would cross eight wetland/riparian areas, and about 34 riparian areas along creeks. It would also parallel creeks in or immediately adjacent to wetland/riparian areas for about 1.8 miles, and riparian areas for about 7.2 miles. No wetlands areas would be affected. In the absence of mitigation, the areas of wetland/riparian vegetation potentially disturbed within the ROW would be about 7.1 acres on NFS lands and 3.5 acres on private and state lands, and the area of riparian vegetation potentially disturbed would be 40 acres on NFS lands. FS mitigation will insist that roads cross riparian areas at right angles, if possible, and that roads parallelling a stream be located outside the riparian areas, if possible. This mitigation would reduce temporary direct impacts to wetland/riparian vegetations to about 0.6 acres, and permanent direct impacts to an additional 0.4 acres, and temporary direct impacts to riparian vegetation to about 2.3 acres and permanent direct impacts to an additional 1.6 acres. Except at stream crossings, riparian vegetation can generally be avoided by relocating the ROW within the transportation corridor, since the transportation corridor is only about 15 percent riparian.

About 20.5 miles of the transportation ROW system would be located on primary or secondary range in grazing allotments, resulting in temporary loss of about 74 acres of forage and permanent losses of an additional 49 acres of forage.

Most of the transportation corridors are in non-range. About 14 miles of the transportation ROW system would affect about 84 acres of potential timber production areas on NFS lands.

The impacts of construction of the flowlines within the transportation ROWs are covered above. However, the 20-foot width required for flowline construction would be revegetated following construction, as described under flowline construction in Alternative A (Section 4.4.2.1). In addition, Alternative C would include the 25.5 miles of currently planned flowline construction described under Alternative A.

Since the proposed compressor station on NFS lands would be located within proposed or existing well sites, no additional direct disturbance of vegetation would occur. However, the proposed compressor station on

private lands would directly disturb 3 acres of vegetation. Minor indirect impacts of the types already discussed may occur during construction.

Operations. The well pads would remain unvegetated until cessation of operations. Well field activities would have little or no impact on surrounding natural vegetation.

Access roads would remain unvegetated for the life of the project. No additional impacts are expected.

Flowline operations may cause a minor disturbance to vegetation during routine or emergency maintenance procedures.

The compressor stations would be equipped with clean-burn control technology, and emissions are unlikely to have any effects on vegetation. Production and disposal of produced water is unlikely to have any effect on vegetation.

Abandonment. The effects of abandonment would be the same as those discussed for Alternative A (Section 4.4.2.1).

4.4.3 Impacts Summary

The primary impacts to vegetation would be the removal of natural vegetation during construction of well pads, roads, pipelines, and other facilities. The approximate total acreage affected on NFS lands would be 46 acres for Alternative A, 271 for Alternative B, and 646 for Alternative C. The total acreage on private and state lands would be 16 acres for Alternative A, 61 acres for Alternative B, and 203 acres for Alternative C. The total area of impact would therefore be about 1.4 percent of the 56,910 acre Study Area under Alternative C, and less than 0.5 percent of the Study Area for the other two alternatives. The area on NFS lands occupied by permanent facilities, and therefore remaining unvegetated, would be 0 acres for Alternative A, 112 acres for Alternative B, and 316 acres for Alternative C. On private and state lands, permanent impacts would be 0 acres under Alternative A, 23 acres under Alternative B, and 92 under Alternative C. The maximum area of permanent impacts would be 0.7 percent of the Study Area under Alternative C.

All of the vegetation types in the Study Area are widely distributed, and no sensitive vegetation (other than wetlands/riparian discussed below) are known to be present. Cottonwood woodland would be affected the most as a percent of its occurrence within the Study Area, about 2 percent, mainly on private lands.

Narrow wetlands and riparian areas occur along many of the streams in the Study Area, and are present within many of the well windows and in the transportation corridors. A summary of potential impacts to riparian and wetland areas is presented in Table 4-7. Under Alternative C, up to 181 acres of wetland and riparian vegetation could be affected on NFS lands in the Study Area. Maximum losses on private and state lands would be up to 60 acres, about 4 percent of the area covered by these types. The Forest Service mitigation and sound engineering practice would require avoidance of these sensitive areas during construction of wells, roads, and pipelines, if possible. Small losses of wetland and riparian areas would occur wherever new roads cross these areas.

Two sensitive plant species occur within the Study Area, and could potentially occur within the affected areas. In the absence of mitigation, construction might eliminate small populations and individuals or reduce the size of larger populations. Botanical surveys prior to construction would identify whether sensitive plant species are present on affected NFS lands, and whether minor route realignments or other mitigation should be required by the FS.

Losses of up to about 1 percent of grazing land and of potential timber production areas in the Study Area would also occur as a result of construction.

Impacts would continue for the life of the project in areas used for well pads or roads. Impacts would be mitigated by revegetation of other areas after construction, and by revegetation of well pads and roads after abandonment.

Impacts to vegetation, grazing, and timber would be lowest with Alternative A, and highest with Alternative C. However, none of the alternatives would result in significant decreases in vegetation cover, losses of wetlands or riparian areas, or decreases in availability of grazing or timber within the Study Area.

TABLE 4-7

ACRES OF IMPACT TO SENSITIVE VEGETATION RESOURCES (WETLAND AND RIPARIAN AREAS) ON NFS LANDS

Facilities	Alternatives					
	A		B		C	
	w/o mit[1]	w/mit[2]	w/o mit	w/mit	w/o mit	w/mit
Well Sites	NA[3]	NA	24	0	126	0
Transportation ROW	NA	NA	15.5	1.2	47	4.9
Flowlines ROW	7.9	0.2	7.9	0.2	7.9	0.2
TOTAL	7.9	0.2	47.4	1.4	180.9	5.1

[1] without mitigation measures applied
[2] with mitigation measures applied
[3] not applicable

4.4.4 Cumulative Impacts

A small portion of the Study Area is currently unvegetated, on existing roads and wells. In addition, portions of the Study Area have been strongly influenced by past land management, including timber harvest, grazing,conversion of land to agriculture, development of irrigation systems, and range improvement. These have resulted in changes in plant community composition and structure, of which the most dramatic is the conversion of native vegetation to communities dominated by non-native species, in agricultural areas and in seeded grasslands and pastures. However, more than 90 percent of the Study Area is still dominated by native vegetation under relatively natural conditions. The three alternatives would slightly decrease the proportion of the area in natural vegetation, and the amount of wetland and riparian vegetation.

Even with successful application of mitigation measures, the amount of unvegetated land would be increased for the long-term under Alternatives B and C. Currently, approximately 180 acres on NFS lands in the Study Area would be increased to 292 acres under Alternative B, including existing roads, new roads, and well pads. For Alternative C, the amount of unvegetated land on NFS lands would be increased to 496 acres. Much smaller increases would occur on private and state lands.

The existing roads cross wetland and riparian zones in a number of places. Approximately 6 acres of wetland/riparian, 10.5 acres of riparian, and 0.5 acres of wetland vegetation on private lands are crossed. The actual areas are smaller, based on field observations, and impacts to wetland and riparian areas have been generally minimized during previous road construction. The area of permanent impacts to riparian and wetland areas will be increased under Alternatives B and C, but the total area affected will still be a small percentage of the amount available in the Study Area.

4.4.5 Mitigation Summary

Mitigation measures required by the FS and BLM (Appendix A-1 through A-4) would generally eliminate or reduce impacts to acceptable levels. Standard conditions include the following:

- Restoration of the ground surface, and revegetation of all disturbed areas of soil with approved seed mixes, fertilizer, and mulch;

- Salvage of topsoil from well pads for later re-use;

- Prevention of erosion, through use of erosion-control devices in disturbed areas, including water bars;

- Avoidance of encroachment on streams;

- Construction limited to dry conditions to reduce compaction and rutting;

- Elimination of noxious weeds on disturbed areas;

- Prevention of fires through restrictions on burning and by use of mufflers or spark arresters on all vehicles;

- Protection and restoration of existing range improvements, including fences;

- Safe handling and storage of fuels, lubricants and other liquids and materials to prevent soil and water contamination;

- Trees to be cut shall be designated by the FS; and

- Control of the use of herbicides.

Additional mitigation measures which should be applied include the following:

- The success of revegetation after abandonment would be monitored by the FS, and repeat applications would be required if revegetation is not successful.

- Ensure that the application, storage, and handling of all herbicides meet federal and state requirements.

- Surveys for sensitive plant species shall be conducted prior to ground surface disturbance, and impacts minimized by avoidance of populations or other appropriate mitigations.

- Streams with riparian and/or wetland vegetation would be crossed at right angles, if possible, by roads and flowlines so that the area of impact would be minimized. Roads and flowlines

paralleling streams would not be placed in riparian or wetland areas, if possible. Attempts will be made to place well pads away from riparian or wetland areas.

- Driving vehicles off of approved roads or outside the construction ROWs shall be prohibited.

4.4.6 Unavoidable Adverse Impacts

Unavoidable temporary losses of natural vegetation, and of forage and timber, would occur on a small portion of the Study Area. Unavoidable minor loss and disturbance of wetland and riparian areas would also occur.

4.5 WILDLIFE AND FISHERIES

4.5.1 Introduction

Wildlife habitats directly affected by development of new well pads, roads, etc., represent a small proportion of all habitats present. However, construction and operation disturbances emanating from these areas reduce habitat effectiveness for wildlife in a larger surrounding area. These disturbance zones vary in width depending on a number of factors including intervening terrain and vegetation, the type and duration of disturbance, the species of wildlife present, and the time of year. Elk and deer are the wildlife species that would be most adversely affected by the development under all alternatives. Adverse effects are primarily associated with disturbances on, and displacement from, winter ranges.

Impacts to wildlife would be greatest onsite, and primarily related to human disturbance and habitat loss. Construction impacts resulting in initial habitat loss and wildlife displacement would be intense, primarily confined to one year for Alternative A, one to two years for Alternative B, and extended over seven years for Alternative C. Operation impacts and disturbances resulting from increased public access would be the most significant wildlife related impacts associated with the project. These indirect impacts would be far greater from a wildlife perspective than the relatively small acreages of habitats directly lost to roads and well pads. Operational impacts, resulting in disturbances to wildlife on important seasonal ranges, would be long-term and in some cases, possibly permanent. Offsite impacts, related to disturbance of wildlife on seasonal ranges, such as highway mortality, habitat loss, and game damage to private property, should be minor relative to on-site impacts.

4.5.2 Direct and Indirect Impacts

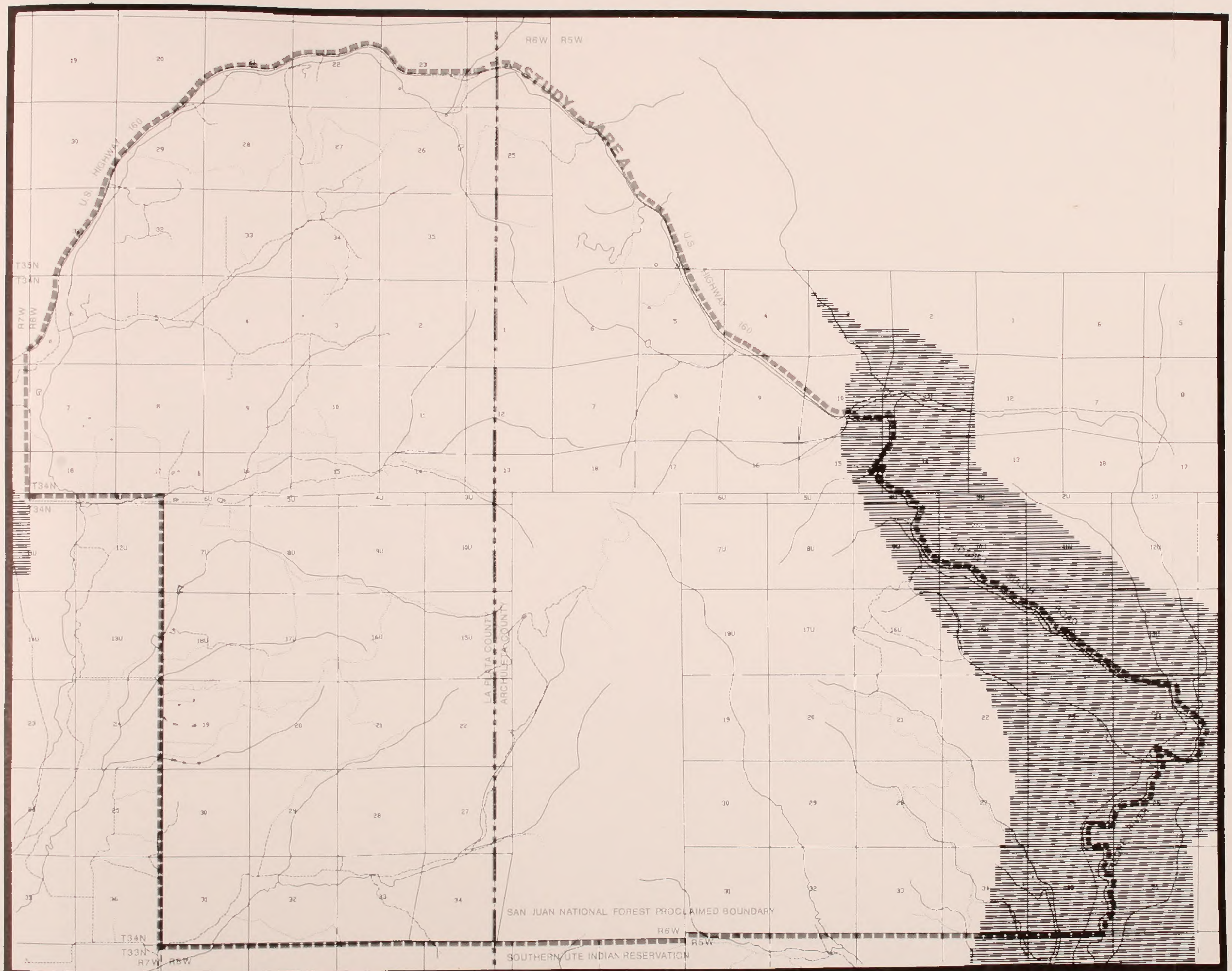
4.5.2.1 Alternative A - No Action

Construction. Under this alternative, the only additional gas development facilities that would be installed in the Study Area would be 25.5 miles of flowlines in the Fossett Gulch Road-Pargin Mountain, Spring Creek, Sauls Creek-Lange Canyon, Spring Creek - Reservoir Canyon, and upper Crowbar Creek areas. The 20-foot wide flowline ROW would be constructed mostly adjacent to existing roads between July 15 and November 15 (Appendix A-1), outside the period of big game winter range occupancy. If flowlines are not installed, there would be no additional gas development construction activities associated with this alternative. Workovers, abandonment, and other operational activities would continue beyond this point and are appropriately discussed in following sections.

Adverse impacts associated with flowline construction within the Study Area include: (1) a minimal loss of habitat values as approximately 62 acres of habitat (46 acres on NFS lands) adjacent to existing roads are converted into a grassland type; (2) temporary displacement of wildlife away from construction areas; and (3) the loss of a few, less mobile, terrestrial wildlife species, such as rodents and herpetofauna (reptiles and amphibians), to construction activities. The significance of the habitat converted to grassland varies with the habitat type lost, the wildlife values associated with that type, and the distribution of that type in the area. With the exception of converting some forest habitats to grassland, impacts associated with flowline construction are short-term, and all are considered minor. No threatened, endangered, or candidate species known to occur within the Study Area should be adversely affected.

Flowline installation along the Fossett Gulch Road would convert approximately 7 acres of willow shrub habitat into grassland within what is probably the overall range and hunting territory of a pair of peregrine falcons (Figures 3-8 and 4-5). However, this habitat conversion should not significantly reduce prey species or hunting opportunities and, therefore, should not significantly affect the falcons.

Approximately 40 percent of the Fossett Gulch flowline ROW occurs within Wildlife Resource Information System (WRIS) designated bald eagle winter range (Figure 4-5). Construction activities should not affect eagle use because (1) eagles are not present during the July 15 to November 15 construction period, (2) habitat conversion should not reduce prey species, and (3) the cottonwoods that would be removed from the ROW do not represent roost trees because of their proximity to the Fossett Gulch Road. Flowline installation in upland areas of the HD Mountains, not identified on WRIS maps but where eagles frequently hunt during winter,



THREATENED AND ENDANGERED SPECIES SENSITIVITY

HIGH SENSITIVITY AREA INCLUDES AREAS OF BALD EAGLE WINTER RANGE AND PEREGRINE FALCON OVERALL RANGE

═ AREA OF HIGH SENSITIVITY

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE **4-5**

SOURCE: CDOW WRIS MAPS 1989

should also not adversely affect eagles because the construction period and eagle occupancy do not overlap and flowline installation is not expected to adversely affect eagle prey.

Black-footed ferrets should not be affected by flowline installation because (1) it is unlikely that they are present in the area, (2) a suitable prey base (a sizeable prairie dog colony) appears to be lacking in the area, and (3) flowlines would not affect prairie dog towns.

Neither the Colorado squawfish, roundtail chub, and bonytail, nor any of the more common game and nongame species presented, should be adversely affected by flowline installation. There is no evidence the bonytail is present in the area. Flowline installation could conceivably influence the Colorado squawfish and roundtail chub, via erosion and sedimentation. Similarly, accidents (e.g., failure of a storage tank) and contamination (from produced water) are not inconceivable events. However, (1) the likelihood of these events occurring has been reduced to small probabilities by the implementation and enforcement of an effective operation plan (Appendix A-1), (2) the amount of any increased turbidity would be insignificant relative to the Piedra River flow regime and baseline levels of erosion from this reach of river, (3) in the case of the squawfish, which does not occur above Navajo Dam, any sediments or contaminants would be contained in Navajo Reservoir, and (4) there would be no local or downstream water depletions resulting from any level of proposed development. Aquatic contamination of any type would be most deleterious at the source; toxicities would decrease as the plume was diluted.

Mexican Spotted Owls and ferruginous hawks, if present in the area, should not be significantly affected by flowline installation. Only 25.2 acres (mixed conifer = 0.8 acre, ponderosa pine = 13.8 acres, pinon-juniper = 10.6 acres) of potentially suitable spotted owl habitat would be converted to grassland, and most of that would be along existing roads. Ongoing 1990 surveys in the Study Area have not detected any spotted owls (Bell, personal communication, 1990). It is unlikely that these habitats along the existing road ROW are of any specified significance to the spotted owl, even if the species is present. Moreover, this acreage is insignificant relative to the vast area of undisturbed potential habitat that would remain in the HD Mountains. Only 16.8 acres (cropland/pasture = 6.5 acres, grassland = 0.9 acre, sagebrush = 9.4 acres) of suitable ferruginous hawk habitat would be temporarily disturbed until reclamation returns the ROWs to comparable productivity.

River otters, which occur in the Piedra and Pine Rivers, should not be adversely affected because flowline construction would not influence their habitats or their prey base. The long-billed curlew, white-faced ibis, and wolverine probably do not occur in the Study Area and, therefore, flowline installation activities would not adversely affect them, their potential habitats, or their potential forage/prey base.

Similarly, none of the management indicator species should be adversely affected to any significant degree. The installation of flowlines would amount to 26 acres of big game winter range converted to a reclaimed grassland habitat. This amounts to only 0.1 percent of the total winter range available in the Study Area. Since flowlines would primarily be located in or next to road ROWs (Figure 2-1), which now provide little effective big game habitat, and would be installed outside of winter range occupancy, there should be no adverse effect associated with flowline construction.

Operations. Operation of the flowline system would generally have no adverse effects on most wildlife groups. Once flowlines are installed, there is little or no maintenance and human activity associated with them. While there may be some wildlife displacement from flowlines because of their proximity to existing access roads, this displacement, for impact assessment purposes, is associated with the roads, not the flowlines.

Disturbance to wintering big game is the most significant potential wildlife impact associated with the different alternatives. If flowlines are not installed, produced water would be removed from wells by truck, causing a minor, increased amount of year-round disturbance to adjacent wildlife habitats for the life of the wells. However, because the installation of flowlines would locally reduce or eliminate the need for trucks to haul water from wells so equipped, the short-term disturbances associated with flowline construction would be offset by the long-term benefit of reduced disturbances by water trucks on access roads. This result would be most beneficial during big game winter range occupancy (approximately November 15 to April 15), but it would also benefit other wildlife groups year-round. In appropriate areas, reclaimed flowline ROWs may have a locally beneficial influence on turkeys through the use of seed mixes specifically oriented toward turkey habitat enhancement (Appendix A-4).

Operational activities associated with 21 existing wells (45 acres) on NFS lands and 22 existing wells (66 acres) on private lands would continue in the Study Area under Alternative A. Wells on NFS and private lands are accessed by 33 and 23 miles (80 and 56 acres) of existing gravel and well access roads, respectively. Past and current gas development activities have affected most wildlife groups in the Study Area to varying degrees. Most impacts have been relatively minor, although reduction of habitat effectiveness of the winter range has probably been the most significant impact (Table 4-8). Big game winter range habitat effectiveness in the Study

Area has been reduced by approximately 6.0 to 22.1 percent as a result of all gas development to date (Table 4-8). Approximately 3.1 to 11.2 percent of this reduction has been due to 230 acres of winter habitats lost to well pads and roads. The remaining 88.8 to 96.9 percent (1,823 to 7,290 acres) is attributed to big game avoidance of habitats proximal to human activities (gas and nongas) on roads and at well pads. These reductions in winter range values do not account for additional losses to nongas-related activities (e.g., agricultural, residential, recreational, etc.), which could not be quantified.

Threatened, endangered, and candidate species have been minimally affected by past human developments in the Study Area. The bald eagle is the only such species known to frequently inhabit the Study Area (Figure 3-8). While the possibility exists that other sensitive species occur within the project area's zone of influence, there have been no reports of gas development activities jeopardizing or adversely affecting any threatened or endangered species in the area. Gas development activities have undoubtedly directly or indirectly resulted in disturbance to bald eagles and in minor habitats loss, but these impacts have not significantly influenced habitat use, nor are they expected to.

Big game has been the wildlife group most affected by gas development activities in the HD Mountains because relatively large numbers of elk and deer concentrate on winter ranges in the Study Area where they are sensitive to chronic and acute human disturbances (Figure 4-6). It has not been the loss of relatively small acreages of important habitat to roads and well pads that have adversely affected elk and deer as much as the disturbances associated with vehicle use on the roads, increased public access, and use of previously unused areas.

Vehicular use of roads adversely affects elk use of adjacent habitats (Burbridge and Well 1976; Hershey and Leege 1976; Leege 1976; Marcum 1976; Perry and Overly 1976; Ward 1975; Ward et al. 1976; Hinschberger et al. 1978; Lyon 1979; Rost and Bailey 1979; and Johnson and Lockman 1981; Johnson et al. 1990). The same studies, based primarily on pellet group densities in zones perpendicular to roads, also can be generally extrapolated to deer; although deer avoidance is typically less than that of elk. The zone of disturbance adjacent to roads that is avoided by elk has been reported as 220 yards to 1.8 miles, depending on the type and use of roads and the adjacent habitat. This zone is not completely abandoned by elk, but the effective use of this area is reduced depending on a number of factors. Greater traffic volume on paved roads through more open habitats generally produces a wider zone of avoidance (Perry and Overly 1976; Hershey and Leege 1976; and Rost and Bailey 1979). Habitat management guidelines for northern Idaho predict 10 to 70 percent reductions

TABLE 4-8

ACRES OF EXISTING DIRECT AND INDIRECT DISTURBANCE TO HABITATS IN THE STUDY AREA

Facilities	Total	Big Game Winter Range	Percentage of Winter Range[a]
On NFS Lands			
Wells (21)	45	43	0.2
Reduced Use[b]	1,694	1,371	5.9
Nonuse 10%	169	137	0.6
Nonuse 40%	678	549	2.3
Nonuse 70%	1,186	960	4.1
Gravel Roads (33 mi)	80	65.1	0.3
Reduced Use[b]	10,640	7,776	33.3
Nonuse 10%	1,064	778	3.3
Nonuse 40%	4,256	3,110	13.3
Nonuse 70%	7,448	5,446	23.3
Off NFS Lands			
Wells (22)	66.0	66.0	0.6
Reduced Use[b]	1,774	1,774	16.7
Nonuse 10%	177	177	1.7
Nonuse 40%	710	710	6.7
Nonuse 70%	1,242	1,242	11.7
Gravel Roads (23 mi)	56	55.5	0.5
Reduced Use[b]	7,416	7,305	68.7
Nonuse 10%	742	731	6.9
Nonuse 40%	2,966	2,922	27.5
Nonuse 70%	5,194	5,117	48.1

TABLE 4-8
(CONTINUED)

Facilities	Total	Big Game Winter Range	Percentage of Winter Range[a]
<u>Study Area Total</u>			
Wells (43)	111	109	0.3
Reduced Use[b]	3,468	3,145	9.2
Nonuse 10%	347	315	0.9
Nonuse 40%	1,388	1,258	3.7
Nonuse 70%	2,428	2,202	6.5
Gravel Roads (56 mi)	136	121	0.4
Reduced Use[b]	18,056	15,081	44.3
Nonuse 10%	1,806	1,508	4.4
Nonuse 40%	7,222	6,032	17.7
Nonuse 70%	12,642	10,556	31.0
Total at 90% HE[c]	2,405	2,053	6.0
Total at 60% HE[c]	8,717	7,520	22.1
Total at 30% HE[c]	15,030	12,988	38.2

[a] Percentage of big game winter range affected on NFS lands, off NFS lands, and entire Study Area; total available winter range is 23,376, 10,633, and 34,009 acres, respectively.

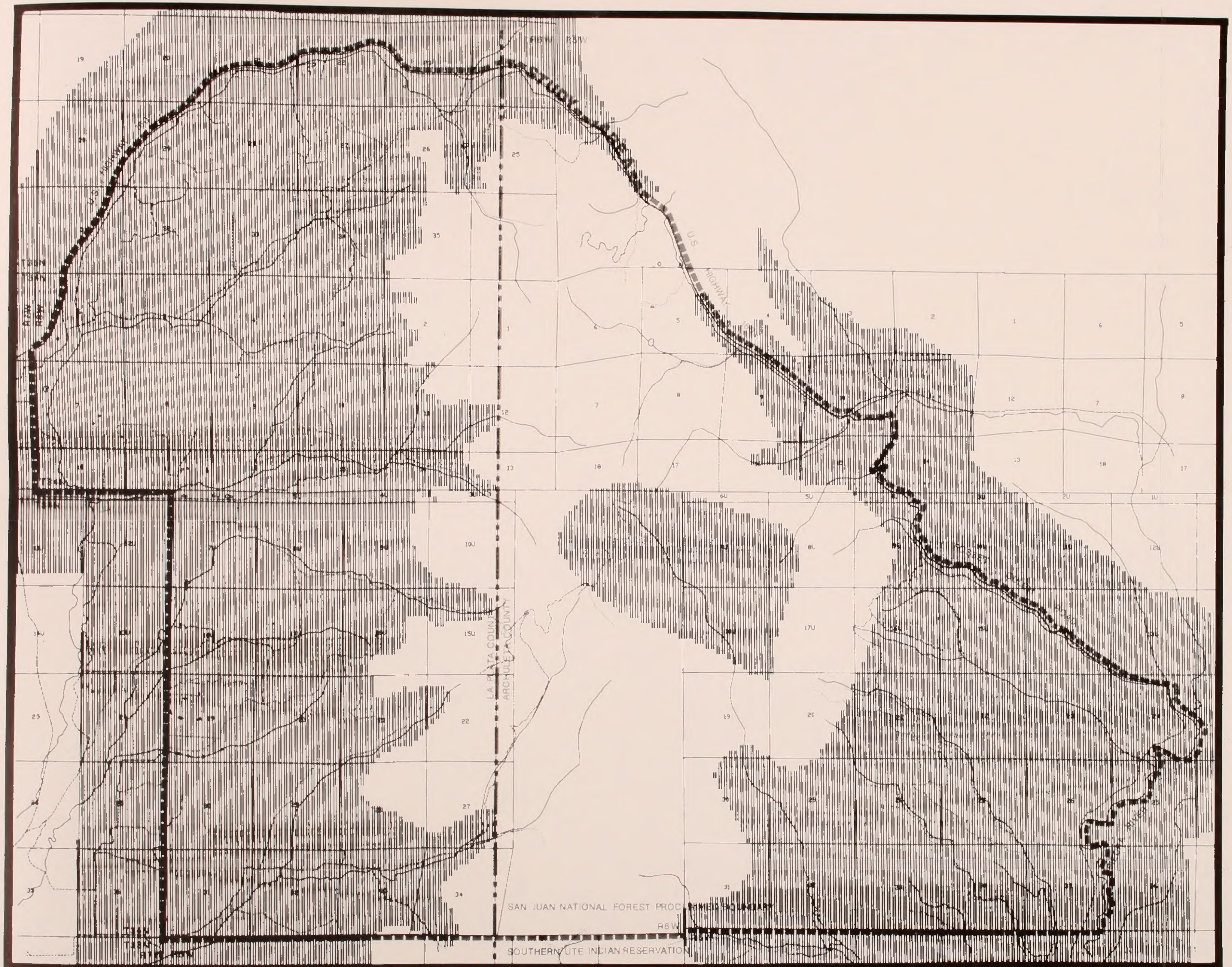
[b] An Interagency Study Team (1977) predicted 10 to 70 percent reductions in elk use of habitats within 0.25 miles of open roads. The 40 percent figure of reduced habitat effectiveness was used as a midpoint.

[c] HE = Habitat effectiveness

in elk use within 0.25 miles of open roads (Interagency Study Team 1977). One-quarter mile is the distance most commonly used to assess the influence of proposed secondary roads, open to the public, on elk habitat effectiveness (Habitat effectiveness [Lyon 1979] is the degree to which habitats adjacent to roads or human activity areas are less than fully utilized because animals are avoiding the associated activities). This zone of disturbance may be narrower for gas development access roads since they may be closed to the public (Perry and Overly 1976), and are infrequently used (e.g., once per day). It should be noted that it is not the roads themselves that elk avoid, but the disturbances associated with human activity along the roads. Elk show little or no avoidance of roads completely closed to vehicular traffic (Marcum 1976). Avoidance is reinforced by unpleasant experiences during the hunting seasons (Geist 1970) and by the perceived threat from vehicles and humans outside the hunting seasons. The above zones of disturbance were developed based on displacement from individual roads. However, cumulative road density can become so great (at 3 to 6 miles of road/square mile) that the availability of effective elk habitat is completely eliminated (Thomas et al. 1979; Lyon 1979). Closing gravel roads open to the public through big game winter ranges can reduce adjacent zones of disturbance and increase habitat effectiveness.

Conversely, elk tolerance/avoidance of human developments and activities varies widely between seasoned ranges based on a variety of factors such as habitat availability and juxtaposition, importance of the habitat, animal condition, and the suitability and availability of adjacent habitats. Buffer zones are generally narrower during winter because winter ranges are aerially restricted, important, and there are few adjacent areas to move to even if the animals could energetically afford to do so. It follows that buffer/avoidance zones should be narrower at the end of the winter than at the start, and narrower during severe winters than during mild winters (i.e., if elk are starving, they will approach human developments and activities more closely to forage). Elk, more so than deer, are also able to travel long distances from cover to exploit forage at night, which is unavailable during the day because of its close propensity to human developments and activities. For this analysis, impacts have been conservative in favor of big game; actual impacts will probably be less than those predicted.

For the HD Mountains analysis, the zone of influence acreage was calculated around existing and proposed gravel secondary roads in the Study Area. Dirt primitive roads were excluded from the analysis because (1) big game show less avoidance of them, (2) because most of these roads in the Study Area are drifted over with snow and rarely used during the period of winter range occupancy, the period of primary importance, and (3) primitive roads were prohibitively difficult to discern from maps and aerial photographs. There are no paved primary roads in the Study Area, although U.S. Highway 160 constitutes the Study Area's northern boundary. Ten, 40, and 70 percent reductions in current elk use adjacent to gravel roads, corresponding to habitat



ELK AND MULE DEER SEASONAL RANGES SENSITIVITY

HIGH SENSITIVITY AREAS INCLUDE AREAS OF THE FOLLOWING SEASONAL RANGES:

ELK RESIDENT POPULATION

ELK AND MULE DEER HIGHWAY CROSSING

ELK AND MULE DEER SEVERE WINTER RANGE

ELK AND MULE DEER WINTER RANGE

ELK AND MULE DEER WINTER CONCENTRATION AREA

MULE DEER WINTER RANGE

|| AREA OF HIGH SENSITIVITY

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE **4-6**

SOURCE: CDOW WRIS MAPS 1989

effectiveness values of 90, 60, and 30 percent, respectively, were used to account for variability between Idaho and Colorado habitats when extrapolating impacts. These percentages are being used because the Idaho study (Interagency Study Team 1977) is the only study that has quantified nonuse relative to simple disturbance. The 40/60 percent values were used as midpoints of the range.

There are an estimated 33 and 23 miles (80 and 56 acres) of existing gravel roads on and off NFS lands in the Study Area, respectively. This represents a mean road density of approximately 0.6 miles of gravel road/square mile on the winter range. Using 0.25 miles on each side of these 20-foot-wide access roads (a 2,660-foot corridor) to quantify the potential zone of reduced habitat effectiveness for elk, the area of reduced use in the entire Study Area is 10,640 and 7,416 acres adjacent to existing FS and other roads, respectively (Table 4-8). This area (18,056 acres) is 133 times the area of the roads themselves and approximately 32 percent of the Study Area. Most importantly, 84 percent of this acreage (15,081 acres; road and zone of disturbance areas) is on big game winter range (44.3 percent of the winter range available within the Study Area) where, during winter range occupancy, disturbances can be most detrimental. Fifty-two percent of the acreage of these roads and adjacent zones of reduced habitat effectiveness running through winter range is on NFS lands.

Although not all disturbances to big game resulting from vehicular activity along NFS access roads can be directly attributed to gas-related activities, most impacts can be directly or indirectly attributed to them. As discussed, vehicular disturbances can be most detrimental during the period of big game winter range occupancy. On a weekly basis, most vehicular activity in the Study Area, particularly in more remote areas, is gas-related. However, during "normal" and "severe" winters, much of the remaining public vehicular use can be indirectly attributed to gas development because most ungated access roads, plowed for gas truck access, would be otherwise closed by snow accumulation and, therefore, would be unavailable for public use.

Gas drilling activity can also adversely affect elk use of adjacent habitats. In northern Michigan, elk became habituated to drilling activity because it was confined to one location, although over 90 percent of the Study Area was forested and escape cover was not a limiting factor (Knight 1980). However, in more open habitats in Wyoming, wintering elk did not habituate to the construction or operation of one drill site located adjacent to a largely undisturbed winter range with "normal" snowpack, but were displaced up to 2.5 miles from the local area (Johnson and Lockman 1981; Johnson et al. in press). Elk established buffer zones at approximately 0.25 miles with intervening forest and 1.5 miles where vehicles were in direct line-of-sight (Johnson, personal communication, 1989). If logging studies can be extrapolated to gas drilling activities, most elk can be expected to maintain buffer zones of 550 to 1100 yards from the drill site (Edge and Marcum, 1985). However, the spatial and temporal disturbances of roads and human activity areas associated with drilling a gas well are

generally far less than disturbances from commercial logging. The chronic, predictable, low intensity disturbances associated with drilling a gas well may allow for a greater degree of tolerance to the drill site and the maintenance of a narrower buffer zone. Drilling personnel frequently report deer and elk close to the well pad, although a large, undetected portion of the herd may still be avoiding the site.

Displacement of elk and deer from a well pad during drilling operations appears to be a more chronic, less obtrusive type of disturbance than the acute, unpredictable disturbances associated with human activities along access roads and the periodic monitoring of gas wells (Burbridge and Neff 1976; Knight 1980; and Johnson and Lockman 1981). Drilling disturbances are also temporarily brief, confined to approximately one 2-week interval. "Workovers" on wells, generally confined to one day/year/well, may represent a disturbance equal to initial well development because the associated activity is intense and local wildlife have inadequate time to habituate to it.

Within the Study Area there are an estimated 45 and 66 acres of disturbed habitats at the 21 and 22 existing well pads on and off NFS lands, respectively. Ninety-eight percent of these existing wells are on some type of big game winter range. Using a 0.25 mile surrounding zone (excluding acreage from the associated gravel access roads) to delineate the potential area of reduced elk use from drilling and well checks, the area of disturbance totals 1,694 and 1,774 acres on and off NFS lands, respectively (Table 4-8). Ninety-one percent of these total 3,468 acres are on some type of big game winter range. This represents 9.2 percent of the available winter range in the Study Area and 5.9 percent of that available on NFS lands within the Study Area.

The combined acreage of existing habitat now occupied by gravel roads and gas wells on and off NFS lands in the Study Area is 125 and 122 acres, respectively (Table 4-8). Approximately 108 and 122 acres of these facilities, on and off NFS lands, occur on some type of big game winter range. Including adjacent zones of disturbance, the total acreage now affected by gas development activities in the Study Area is 12,459 and 9,312 acres, respectively, on and off NFS lands. Eighty-five percent (18,456 acres) of this affected acreage occurs on big game winter range, representing 54 percent of the total winter range available (34,009 acres) within the Study Area. Maintenance of critical habitats, such as big game winter ranges, on public land is important because the viability and availability of those habitats on private lands cannot be guaranteed in perpetuity.

At 90 percent, 60 percent, and 30 percent habitat effectiveness values (corresponding to 10 percent, 40 percent, and 70 percent nonuse of habitats within 0.25 miles of existing roads and wells), the existing reduced carrying capacity of HD Mountains big game winter ranges totals 6.0 percent, 22.1 percent, and 38.2 percent, respectively, of the total available winter range (Table 4-8). Given the relatively low amount of existing gas

development in the Study Area, the compatibility of other human developments with big game winter range, and the extent to which elk in the HD Mountains have habituated to chronic human activity on winter ranges, the 90 percent habitat effectiveness value is probably the most appropriate percentage to use for evaluating the impact of human developments in this Study Area.

Public vehicle use on ungated roads built to access gas wells can have a similar, additive, or possibly a synergistic influence on reducing big game use of adjacent habitats, as well as causing additional impacts. Public access to isolated road systems on big game winter range increases the potential for illegal harvest. Poaching is a significant problem in some areas of the HD Mountains. It was estimated that from 100 to 150 deer had been poached in a single year in Game Management Unit (GMU) 751, with much of it occurring along the Spring Creek Road System (Carron, personal communication 1989), which represents the longest public access in the HD Mountains and which penetrates the furthest into the interior, upper elevations of the mountain range. Increased public access through an expanded road system can also increase legal harvest of wildlife. This is advantageous when the management goal is to stabilize or reduce herd numbers, but detrimental when the management goal is a conservative harvest to permit herds to increase or recover after a severe winter.

Using the 90 percent habitat effectiveness value, 93.9 percent of the big game winter ranges in the Study Area are still available after all past losses from gas-related developments. Winter range losses and disturbances from FS and private roads, private residences, restrictive fencing, agricultural activities, etc., have not been quantified, but probably amount to an additional 5 to 10 percent. Thus, the total of presently available winter range acreage is approximately 84 to 89 percent of what would be available without any human developments or presence in the Study Area.

The result of implementing Alternative A should be no significant, development-induced changes in elk or deer numbers or in seasonal habitat use patterns, although past gas development activities may have had significant local effects. Big game numbers would fluctuate under the influence of winters of varying severity and CDOW management.

Past and present gas development activity has probably produced some disturbances to black bear habitats in the HD Mountains. However, upper elevations in the Study Area are relatively undeveloped and still provide important escape terrain close to the extensive oakbrush concentrations. Bear populations are thought to have declined in recent years due to overharvest. Increased harvest may have been facilitated by increased accessibility on roads created to access gas wells. Overexploitation in this important bear range is probably the factor having the greatest adverse effect on local bear numbers and on those in the surrounding area.

Minimal conversion of peripheral habitats to grassland in flowline ROWs should not cause any significant impacts on bears as part of Alternative A.

Wild turkeys have been increasing their numbers in the Study Area coincident with gas development activities. Implementation of Alternative A is not expected to alter this trend. Flowlines would result in some minor habitat loss, 15.3 and 10.8 acres, respectively, which would occur within turkey winter ranges or winter concentration areas on and off NFS lands, respectively (Figure 4-7). These combined acreages of direct disturbance represent only 0.1 percent of the total acreage of turkey winter range and winter concentration areas available within the Study Area and a much smaller percentage of these ranges available beyond the Study Area boundary. ROWs in appropriate areas would also be revegetated with a seed mix beneficial to turkeys. This would yield a minor positive influence. Flowline ROW clearing is not expected to remove any roost trees. Although construction and operational disturbances would extend beyond wellpads and ROW corridors by some unknown distance, the resulting impacts are not expected to significantly alter turkey numbers or habitat use.

Hairy woodpeckers, and the other wildlife that this forest indicator species represents, should not be significantly affected by implementation of the alternative because only 22 acres of forested habitats in the Study Area would be altered by flowline installation. Similarly, green-tailed towhees and species with similar habitat affinities should experience no significant impacts associated with gas development activities under this alternative, because only 6 acres of oakbrush and minor acreages of other habitats occupied by this species would be converted to grassland. The influence of continuing gas operational activities should not alter the use of the Study Area by wildlife represented by these two species.

Other wildlife groups, including fish, raptors, waterfowl and shorebirds, predators and furbearers, and nongame birds, mammals, and herpetofauna, may have been influenced to varying degrees by past and current gas development activities in the HD Mountains. However, gas-related activities associated with Alternative A are not expected to produce any appreciable positive or negative changes to numbers or habitat use of these groups.

Abandonment. Following completion of production operations, the well field and ancillary facilities would be reclaimed and abandoned. Wellpads would be removed and the areas revegetated. Roads would be removed and revegetated, or retained, based on management goals and requirements of the FS and other landowners. Buried flowlines would be left in place. Roads and wellpads would be revegetated with seed mixes approved by the FS, some of which are specifically oriented to enhance wildlife use. Natural succession would gradually

WILD TURKEY SEASONAL RANGES SENSITIVITY

HIGH SENSITIVITY AREA INCLUDES AREAS OF WILD TURKEY WINTER RANGE AND WINTER CONCENTRATION

AREA OF HIGH SENSITIVITY

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

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SPRING 1990

FIGURE 4-7

SOURCE: CDOW WRIS MAPS 1989

return reclaimed areas to communities similar to undisturbed areas. Impacts to wildlife, primarily displacement, resulting from abandonment activities would be short-term and comparable to those associated with well-workovers and initial road construction.

4.5.2.2 Alternative B - Proposed Action

Impacts to wildlife and their habitats under Alternative B would be greater than those resulting from Alternative A. Impacts would be primarily confined to those onsite that are related to human disturbance and habitat loss. While direct impacts associated with ROW and well development would adversely affect some important seasonal habitats, the acreage of habitats disturbed would be small relative to the total acreage of habitats available in the Study Area. This holds true even when direct impacts from all gas development in the Study Area (past and future) are considered. However, as in Alternative A, the most significant potential impacts resulting from implementation of Alternative B would be related to construction and operational gas activities which reduce the effectiveness of adjacent wildlife habitats. Potential impacts would be greatest on big game (elk and deer). Potential impacts may be excessive if appropriate and required mitigation measures are not implemented and if public access is not restricted on roads into sensitive habitats during periods of occupancy. With the implementation of recommended and required mitigation measures (Appendixes A-1 and A-4), potential impacts would be reduced to levels that should not appreciably alter present big game numbers or habitat use patterns.

Construction and Operations. Implementation of Alternative B would result in long-term changes to 332 acres (0.6 percent) of the Study Area as a result of facilities installations (Table 2-3). The largest acreages of individual vegetation types to be converted to wellpads, roads, and reclaimed areas include pinon-juniper, ponderosa pine, oakbrush, and sagebrush. These four types account for over 90 percent of the acreage that would be directly disturbed.

Bald eagles and peregrine falcons are the two threatened, endangered, or candidate species considered in this document which are known to have seasonal ranges overlapping the Study Area (Figure 4-5). Alternative B's construction and operational disturbances may result in minor disturbances to these two species. However, these effects should not be significant for the reasons specified under Alternative A. No habitat within bald eagle winter concentration areas would be directly affected. Indirect effects should not appreciably exceed present levels. Acreage of eagle winter range directly affected by well windows and ROWs totals 63.3 acres (9.0 percent of the winter range in the Study Area), all but 1.5 acres of which would occur on private lands. A pair of peregrine falcons, whose eyrie outside the Study Area is buffered from the effects of gas development

in the HD Mountains, would have 176.6 acres of their overall range in the Study Area (3.9 percent) altered by flowline ROW and well development. Most (100.3 acres) of the habitat loss would occur on NFS lands; however, the proportion of the peregrine's overall range within the Study Area represents a small fraction of the overall range extending beyond the Study Area boundary. No habitats within the WRIS designated hunting territory of the inactive Chimney Rock eyrie would be directly affected by gas activities. Indirect impacts should be close to current levels.

Impacts to the other threatened, endangered, or candidate species considered in this document should only be minor, at most, because (1) it is unlikely that the species seasonally occurs in the Study Area (e.g., black-footed ferret, ferruginous hawk, wolverine, and river otter), or (2) if it does, direct and indirect disturbances would be relatively small and mostly confined to lower Study Area elevations and to habitats of limited value to the species (e.g., long-billed curlew and white-faced ibis), or (3) adherence to the operating plan reduces the probability of potential impacts to any offsite species (e.g., Colorado squawfish, river otter, roundtail chub, and bonytail) to acceptable levels.

Thus far, ongoing 1990 surveys in the Study Area have not detected the Mexican spotted owl. Potential habitats of this species would be affected proportionately more by Alternative B than by Alternative A because of the greater acreage of habitat that would be influenced by construction and operations.

Elk and deer would be the wildlife species most affected by Alternative B gas development activities. Elk would be displaced from construction and operational activities further than deer. Impacts would be primarily due to human disturbances and reduced habitat effectiveness on winter ranges and, to a minor extent, to direct habitat losses and additional indirect onsite affects.

Direct loss of big game winter range would minimally affect elk or deer under Alternative B. Total acreage of winter ranges disturbed for the life of the project by installation and use of flowlines, well pads, and road/flowline ROWs would total 332 acres, or 1.0 percent of the winter range available within the Study Area (Table 4-9). This acreage is approximately 5.4 times greater than what would be directly disturbed under Alternative A. Eighty-two percent (271 acres) of this acreage would be on NFS lands, representing 1.2 percent of the winter range available on NFS lands within the Study Area.

Displacement of wintering big game resulting from short-term construction and long-term operational activities would be greater than the effects of direct habitat loss. The zone of disturbance surrounding gas field facilities (including roads) that would experience varying degrees of reduced habitat effectiveness, would total 5,698

acres of winter range, or 16.8 percent of the winter range available within the Study Area (Table 4-9). Only 2.0 percent (113 acres) of this loss would be on private lands. Reduced use on NFS lands would total 5,585 acres, or 23.9 percent of the FS winter range within the Study Area. These figures do not include acreage lost to past natural gas development activities (see Section 4.5.2.1).

While this zone of disturbance reflects an area of reduced use, it does not represent an area of nonuse. In Idaho, habitat management guidelines developed by an Interagency Study Team (1977) predicted 10 to 70 percent reductions in elk use within 0.25 miles of open roads. It appears valid to directly extrapolate these percentages to HD Mountains roads open to the public, as well as gated gravel roads that experience less vehicle use, because there is still a routine use of these latter roads by Amoco personnel and contractors. A probable 10 percent reduction in elk use within 0.25 miles of new roads and wells within winter range would result in 570 acres of nonuse, or 1.7 percent of the winter range available within the Study Area (Table 4-9). Ninety-eight percent of this area (559 acres) would be on NFS lands. A possible 40 percent reduction (intermediate between 10 and 70 percent, used for comparative purposes) in elk use would result in 2,278 acres of winter range lost for the life of the project. This area would represent 6.7 percent of winter range within the Study Area. Ninety-eight percent of this loss would be on NFS lands, representing 10.0 percent of FS winter range in the Study Area. An unlikely 70 percent reduction in elk use would result in long term nonuse of 3,990 acres of winter range, or 11.7 percent of the total winter range within the Study Area. Some wintering animals could probably be accommodated on winter ranges off the Study Area without adverse effect. However, use of private lands would likely increase damage claims both on and off the Study Area. Again, 98 percent of this loss would be on FS controlled winter range, or 16.7 percent of FS winter range available within the Study Area.

The total effect of Alternative B gas development activities could be a small to moderate reduction in available big game winter range (Table 4-9) if recommended mitigation is not implemented. The vast majority of disturbed acreage would occur on NFS lands. For all lands within the Study Area, gas-related impacts could result in the long term loss of 2.6 (902 acres) to 12.7 (4,322 acres) percent of the available winter range (Table 4-9). Losses on NFS lands could range from 3.6 (830 acres) to 17.9 (4,184 acres)percent of all winter range available within the Study Area. These estimates do not include habitat losses from past gas activities or from non-gas-related human developments.

TABLE 4-9

ACRES OF PROPOSED DIRECT AND INDIRECT IMPACTS TO BIG GAME WINTER RANGES IN THE STUDY AREA

	ACRES (% of Study Area) AFFECTED		
Alternative Facility	On NFS Lands	Off NFS Lands	Total
TOTAL WINTER RANGE[1] AVAILABLE	23,376 (100%)[2]	10,633 (100)	34,009 (100)
Alternative A			
Flowlines Row	46 (0.1)	16 (0.1)	62 (<1)
Alternative B			
Flowlines Row	46 (0.1)	16 (0.1)	62 (<1)
Well Sites	84 (0.1)	18 (0.2)	102 (<1)
Transportation ROW	141 (0.6)	27 (<1)	168 (<1)
Reduced Use[3]	5,585 (23.9)	113 (1.1)	5,698 (16.8)
Nonuse 10%	559 (2.4)	11 (0.1)	570 (1.7)
Nonuse 40%	2,234 (10.0)	44 (0.4)	2,278 (6.7)
Nonuse 70%	3,913 (16.7)	77 (0.7)	3,990 (11.7)
Total at 90% HE[4]	830 (3.6)	72 (0.7)	902 (2.6)
Total at 60% HE[4]	2,505 (10.7)	105 (1.0)	2,610 (7.7)
Total at 30% HE[4]	4,184 (17.9)	138 (1.3)	4,322 (12.7)
Alternative C			
Flowlines Row	46 (0.1)	16 (0.1)	62 (<1)
Well Sites	285 (1.2)	63 (4.6)	348 (1.0)
Transportation ROW	315 (1.3)	124 (<1)	439 (1.3)
Reduced Use[3]	8,072 (34.5)	304 (2.9)	8,376 (24.6)
Nonuse 10%	807 (3.5)	30 (0.3)	837 (2.5)
Nonuse 40%	3,229 (13.8)	122 (1.1)	3,351 (10.0)
Nonuse 70%	5,650 (24.2)	213 (20)	5,863 (17.2)

TABLE 4-9
(CONTINUED)

Alternative Facility	ACRES (% of Study Area) AFFECTED		
	On NFS Lands	Off NFS Lands	Total
Total at 90% HE[4]	1,360 (5.8)	237 (4.8)	1,618 (4.7)
Total at 60% HE[4]	3,782 (16.2)	329 (3.1)	4,132 (12.1)
Total at 30% HE[4]	6,203 (26.5)	420 (3.9)	6,644 (19.5)

[1] Includes elk and mule deer winter range, severe winter range, and winter concentration areas within the Study Area
[2] Areas affected (percentage of area)
[3] Reduced habitat effectiveness within 0.25 miles of roads and wells
[4] HE = Habitat effectiveness

While potential impacts to big game winter range use under Alternative B could be low to moderate, implementation of recommended and required mitigation measures (Section 4.5.5) would reduce impacts to acceptable levels. Measures which have the most beneficial effects are those listed under Operations (Section 4.5.5.1), specifically, the seasonal closure of all new roads to public vehicle use and the closure of some existing roads (Sauls and Spring Creek). These measures would reduce the number of vehicles disturbing big game on winter range as well as reducing the potential for poaching. While the acreage of disturbance zones adjacent to roads would not change as a result of restricting public access because of routine use by gas company personnel, the frequency and type of disturbance would be reduced behind locked gates, thus increasing habitat effectiveness. Amoco employees and contractors have all completed wildlife awareness programs identifying what impacts to big game are, and ways to reduce these disturbances. Restricting public vehicle access should increase the availability (effectiveness) and use of habitats behind locked gates.

Other seasonally important big game habitats should not be appreciably affected by implementation of this alternative. Calving/fawning areas, whose distributions in the Study Area are poorly known, are thought to occur at higher elevations beyond much of the gas-related disturbances or outside of the Study Area to the north of U.S. Highway 160. Construction and operational activities and facilities should not block or appreciably alter big game movement patterns or increase the incidence of mortality on highways surrounding the Study Area.

Expansion of gas development activities under Alternative B would produce additional minor direct and indirect impacts on black bears seasonally inhabiting the HD Mountains. Direct impacts should be confined to long-term habitat alterations from facilities development. Of most concern would be the loss of oakbrush, probably the most important habitat type for bears in the Study Area. However, that habitat is widespread in the Study Area, especially at upper elevations where little additional gas development activity is proposed under this alternative.

Operational impacts (from disturbance) could be equally or more severe than direct habitat losses. Construction and operational activities could displace bears from a relatively large surrounding area of habitat. In addition, if new and some existing access roads do not restrict public vehicle use, increased public access, particularly during the spring bear season, may exacerbate the exploitation problem in an already declining bear population.

Implementation of Alternative B probably would not alter the trend of increasing turkey numbers and distribution in the Study Area. A total of 604.1 acres of turkey winter range and winter concentration areas would be altered by development activities (Figure 4-7); however, this represents only 4.6 percent of those habitats

available within the Study Area and a smaller percentage of those ranges available on surrounding public land. Seventy-six percent of this winter range loss within the Study Area would be on NFS lands, representing 4.6 percent of the available FS winter range. Closures of access roads to public vehicle use, roost tree protection, and revegetating disturbed areas with a turkey seed mix would reduce development impacts to turkeys.

Hairy woodpeckers and the forest species they represent should not be appreciably affected by the gas development proposed under Alternative B. Although forested habitat would be altered by development activities, impacts should be minor because (1) the loss of trees would be confined to small areas (3 acres or less) and narrow linear corridors, (2) these clearings would be spread out over a large area, rather than occurring in one or two large sites, and (3) the acreage lost would be small relative to the remaining forested land within the Study Area. Similarly, "shrubby species", represented by the green-tailed towhee, should not be appreciably affected because of the relatively small acreages of brushy habitats that would be altered by development activities.

Other wildlife groups, including raptors, waterfowl and shorebirds; predators and furbearers; fish; and nongame birds, mammals, and herpetofauna may be influenced to minor degrees by direct and indirect gas-related impacts under this alternative. Direct impacts would include losses of small, less mobile wildlife to local construction activities and 332 acres of long-term habitat losses. Indirect impacts would include increased disturbance of wildlife, displacement of more sensitive species and groups from areas adjacent to disturbances, and possible increased harvest of game, predators, and furbearers. Operational impacts would be reduced if access roads are closed to public vehicle use.

<u>Abandonment</u>. Impacts to wildlife associated with revegetation and abandonment operations will be the same as those discussed under Alternative A. However, because a greater acreage of gas-related developments will be reclaimed under Alternative B, short-term displacement of wildlife from reclamation operations will be proportionately greater under Alternative B.

4.5.2.3 Alternative C - Current Direction

Impacts to wildlife and their habitats resulting from gas development under Alternative C would be the greatest of all alternatives considered. Habitats directly lost for the long term to development activities would still be small relative to the total area available. These losses would also be spread out over virtually the entire Study Area, thereby reducing the impact on any local area. However, operational and construction disturbances evenly disbursed throughout the Study Area would significantly reduce available refuge and habitat effectiveness

for sensitive wildlife species resulting in adverse effects. Elk and deer are the wildlife species that would be most affected by this level of development through reduced use of winter range and other indirect impacts. Recommended mitigation measures would reduce potential impacts.

Construction and Operations. Implementation of Alternative C would result in long term changes to 849 acres (1.5 percent) of the Study Area (Table 2-3). The largest acreages of individual habitat types to be converted to wellpads, roads, and reclaimed areas are ponderosa pine, oakbrush, pinon-juniper, sagebrush, mixed conifer, and cropland/pasture.

Threatened and endangered species seasonally present, or potentially present, should not be significantly affected by gas development under Alternative C, although some species may be affected to minor degrees (Figures 2-7 and 4-5). Habitat alterations within the overall range of the inactive Chimney Rock peregrine falcon eyrie should not significantly degrade potential hunting habitat. Similarly, if habitats flanking the Piedra River are within the hunting territory of the Piedra peregrines, habitat modifications within the area should not adversely affect hunting opportunities because of the relatively small acreage involved. It could be argued that the openings created in forested habitats would expose more prey to attack, but this potential benefit would also be minor.

Acreage of bald eagle winter range directly affected would total 63.5 acres, 9.0 percent of that available within the Study Area. Approximately 27 percent of this affected winter range (17 acres) is on NFS lands, 7.8 percent of that available. No bald eagle winter concentration areas would be directly affected. Bald eagles feeding on winter killed ungulates in the Study Area may experience more disturbance from increased and more widespread operational activities. Availability of winter-killed ungulates may change if gas development activities affect a decline in big game populations. However, this effect is probably insignificant relative to the influence that severe versus mild winters have on the availability of carrion.

It is unknown if Mexican spotted owls occur in the HD Mountains. Potential habitats of this species would be affected more by this alternative than by any other because of the greater acreage of habitats altered and the more widespread and protracted construction schedule. Thus far, however, 1990 surveys in the Study Area have not detected the species.

Other threatened, endangered, and candidate species present or potentially present within the project's zone of influence should not be significantly affected by development under this alternative.

Elk and deer would be the wildlife species most affected by gas development activities under Alternative C. Impacts would be more severe under Alternative C than for either Alternatives A or B due to greater and more widespread disturbance of big game on winter ranges and greater direct loss of winter range habitats. Elk would probably be more adversely affected by direct and indirect impacts than deer. Total potential impacts would result in a moderate reduction of winter range habitat effectiveness levels. Implementation of mitigation measures would further reduce impacts.

Direct loss of big game winter range would affect elk and deer under Alternative C to a minor degree. Total acreage of additional winter range disturbed for the life of the project by flowlines, well pads, and road/flowline ROWs would total 849 acres, or 2.5 percent of the winter range available within the Study Area (Table 4-9). This acreage is approximately 13.7 and 2.6 times greater than what winter range would be directly disturbed under Alternatives A and B, respectively. Seventy-six percent (646 acres) of this winter range loss would occur on NFS lands, representing 2.8 percent of the FS winter range available within the Study Area.

Operational impacts to big game, resulting from a seven year construction period and long-term operational disturbances, would be far greater than direct impacts. If unmitigated, these impacts by themselves could be moderate to high. Disturbances from construction and operational activities will reduce big game use in 8,376 acres (24.6 percent) of adjacent winter range within the Study Area (Table 4-9). Over 96 percent of this reduced use will be on NFS lands, representing 34.5 percent of the FS winter range available within the Study Area. These numbers are slightly higher, but not proportionately different, than those of Alternative B, because while Alternative C would directly disturb more acreage, much of the additional acreage is at higher elevations in the Study Area and above big game winter ranges. These numbers do not reflect the acreage of winter range already affected by past gas activities or from other developments within the Study Area (see Section 4.5.2.1), or from implementation of mitigation measures.

As mentioned previously, these disturbances would result in reduced use of adjacent areas, which differs from nonuse. Reduced use may vary from 10 to 70 percent within 0.25 miles of roads and activity areas (Interagency Study Team 1977). These percentages and an intermediate 40 percent reduction have been used to quantify the acreage of nonuse. A possible 10 percent reduction in elk use within 0.25 miles of new roads and wells on winter range would result in an additional 837 acres, or 2.5 percent of the Study Area winter range lost for the long-term due to development (Table 4-9). Ninety-six percent of this loss would occur on NFS lands. A probable 40 percent reduction in use would result in 3,351 acres (10.0 percent) of the Study Area winter range no longer available for the life of the project. This loss would be primarily (96 percent) on NFS lands, representing 13.8 percent of the available FS winter range. An unlikely 70 percent reduction would

displace elk and deer from 24.2 percent of the available NFS winter range and a total of 5,863 acres (17.2 percent of the winter range) within the Study Area. While elk would probably be displaced from these disturbances more than deer, elk displaced from presently occupied portions of their winter range may eventually competitively displace deer from isolated areas.

The total effect of these construction and operational impacts from Alternative C gas development would be a small to moderate reduction in available big game winter range if appropriate mitigation is not implemented (Table 4-9). For all land within the Study Area, these gas-related impacts could result in the long-term loss of 4.7 (1,618 acres) to 19.5 (6,644 acres) percent of the presently available winter range. Virtually all these habitat losses would occur on NFS lands. Losses on NFS lands could range from 5.8 (1,360 acres) to 26.5 (6,205 acres) percent of all winter range within the Study Area. Some, but not all, animals displaced from winter ranges on the Study Area could probably be accommodated on adjacent, offsite winter ranges without adverse effect. Again, these estimates do not consider winter range acreage lost from past gas activities or from other developments.

While the implementation of recommended and required mitigation measures (Section 4.5.5) would reduce Alternative C impacts, it is uncertain that impacts would be reduced to minor levels that are considered acceptable. The most important mitigation measure is the closure of all new roads and some existing roads to public vehicle use during the period of winter range occupancy. This would greatly reduce the number of vehicles disturbing big game as well as reducing the potential for poaching. Although the acreage of disturbance zones adjacent to roads would not decrease as a result of restricted public vehicle access, the habitat effectiveness within that zone would probably increase. Nevertheless, when zones of disturbance adjacent to existing and proposed gas developments are plotted for Alternative C, there is no contiguous area of undisturbed winter range that even approaches one square mile remaining within the Study Area. For this reason, gas development activity proposed under Alternative C would probably result in a minor to moderate reduction of big game winter range, even if all mitigation measures are implemented.

Other seasonally important big game habitats would also be affected by Alternative C development, but only to a minor degree. Most of the elk and deer wintering in the Study Area are thought to calve/fawn outside the Study Area. For those animals that remain to give birth, habitat alterations and disturbances would displace some elk and deer from traditional onsite birthing areas. It is likely that those displaced animals can be accommodated elsewhere (onsite and offsite) without a decrease in realized recruitment. Facilities and construction and operational disturbances would increase the number of obstacles that migrants must negotiate; however, they should not block or significantly alter big game movement patterns or increase the incidence of highway

mortality. Well and road development and operational disturbances would result in habitat losses on elk and deer summer ranges, and reduced habitat effectiveness in adjacent areas. Disturbances (to birthing areas and summer ranges) would result from increased public access and use, as well as from gas activities, if gates do not restrict public vehicle use. While this may alter present summer use patterns, this by itself would probably not adversely affect numbers of big game summering in the Study Area.

While adverse wildlife impacts associated with gas development may be moderate and long-term, they should not be permanent. Conceivably, in 30 to 40 years, all gas wells and access roads will have been removed and the areas reclaimed. The chronic, year-round operational activities associated with the gas facilities would cease and wildlife could return to former use patterns. One persistent feature of past gas development that could continue adversely affecting wildlife would be disturbances associated with increased public access on the expanded road system. However, at that point, discussions between resource agencies could evaluate the suitability of those roads relative to multiple use goals. Of course, the time frame could be protracted if technology and/or economics permit development of remaining unexploited gas resources.

The effect of all Alternative C impacts may be a small to moderate long-term decrease in the number of elk and deer that now winter in the Study Area. This trend may reverse itself once energy extraction is completed in the Study Area and disturbed areas are reclaimed. The amount and availability of winter range is thought to be the most important factor restricting the present size of local elk and deer populations. Assuming that elk and deer numbers are at carrying capacity of the winter range in the Study Area (this is a critical assumption), the best current information predicts a 4.7 to 12.1 percent decrease in the availability of winter range without mitigation (Table 4-9). If unmitigated, this should eventually cause a proportionate reduction in big game numbers if animals cannot be accommodated offsite. If the herds are below carrying capacity the decline may not be as large, or occur at all; if herds are above carrying capacity the reduction may be larger. Any decline would most likely occur during the latter part of a severe winter when abnormally large numbers of deer and elk starve and are killed on highways. Most would attribute the die-off to the severe winter conditions, but it would more accurately be due to an inadequate amount of available winter range. The reduced availability of winter ranges on NFS and other land within the Study Area should also be manifested by an increased incidence of damage claims to agricultural areas west and south of the Study Area.

The above impact assessment is based on the critical assumption that elk and deer numbers are at or near equilibrium with the carrying capacity of the habitat. Based on available information that appears to be the case, but we are not certain. It is difficult to accurately estimate carrying capacity and animal population numbers, and then relate the two. Like animal populations, the availability of winter forage can fluctuate

widely, even among identical winters. For example, despite mild conditions during the 1989/90 winter, there was less forage available for wintering big game because drought conditions during the 1989 growing season resulted in below normal biomass production.

As a result, there is some variability in the response of elk to winter range availability depending on winter severity and to what extent the herd is in balance with the winter range. For example, the local elk herd may now be at equilibrium with winter range during a "normal" winter. The loss of 10 percent of that range to development activities may not immediately precipitate a decline if there are a successive number of "mild" winters. Conversely, the herd may now be in balance with the winter range available during the "mild" winters which have occurred over the last 10 years. The reduced area of winter range that would be available during "normal" or "severe" winters may then cause a die-off, even without any additional winter range lost to development.

Expansion of gas development activities under Alternative C would result in additional direct and indirect impacts adversely affecting black bear use of the Study Area. There is inadequate data, however, to predict whether these impacts with or without recommended mitigation would result in reduced bear use in the HD Mountains. Direct impacts would be entirely associated with habitat losses, including oakbrush, the most important late summer habitat type for bears in the Study Area. However, indirect impacts would likely be more significant. Under Alternative C, new construction and operational disturbances would intrude into all but the highest elevations of the Study Area, formerly undisturbed and inaccessible. These refugia, where bears could retreat to sleep during the day, would be greatly reduced in area by the widespread, evenly spaced gas wells and ancillary facilities. This would reduce the suitability of much of the Study Area. An expanded road system, closed to public vehicle access or otherwise, would increase hunter access in the area, potentially exacerbating the overexploitation problem in a bear population that is presently declining.

Implementation of Alternative C would adversely affect wild turkeys, possibly to the extent of slowing the present trend of increasing numbers in the Study Area (Figures 3-10 and 4-7). This would result from the long-term loss of 2,148 acres (11.7 percent) of turkey winter range in the Study Area. Approximately 44 percent of this lost winter range would occur on NFS lands, representing 6.7 percent of the FS winter range available in the Study Area. Reduced use will also occur on a larger area of adjacent winter range due to avoidance of construction and operational disturbances. Use of turkey seed mixes on reclaimed areas would benefit turkeys, although public vehicle access on new roads and increased hunter access would produce detrimental effects.

Cavity-nesting species, represented by the hairy woodpecker, would be adversely affected by the direct loss of forested habitat in the Study Area. While this loss would represent a small proportion of the total forested acreage available in the Study Area, and the spatial arrangement of these losses would be dispersed thereby avoiding significant local impacts, this is a large acreage used by moderate numbers of birds. Direct habitat losses and the loss of eggs/nestlings would be the most significant impacts to this group. Snags occupied by primary and secondary cavity nesters would be destroyed by construction activities. This habitat loss would also result in locally reduced foraging habitat and future nest trees. Indirect impacts should be insignificant. The effect of these habitat losses and reduced recruitment during one breeding season may be minor local declines in cavity nesters; however, these numerical changes would probably not be discernable from natural fluctuations in the Study Area.

"Shrubby species," represented by the green-tailed towhee, would be adversely affected to a similar degree by the loss of "shrubby" vegetation. While this habitat loss would be proportionately greater because "shrubby" habitats are less widespread in the Study Area, the loss is still relatively minor. Localized reduced recruitment and habitat losses would probably not affect numerical changes that are discernable from annual variations.

Other wildlife groups, including raptors, waterfowl and shorebirds; predators and furbearers; fish; and nongame birds, mammals, and herpetofauna would be adversely influenced to minor degrees by direct and indirect gas related impacts. Impacts to these groups would be greater under Alternative C than under other alternatives. Fish would probably be least affected since none occur onsite, erosion control measures would be effective, and there would be no offsite water depletions. Direct impacts would include long-term changes to 852 acres of habitat and the loss of some small mammals, herpetofauna, and bird nests to construction activities. Indirect impacts would include increased and more widespread year-round disturbance of wildlife, displacement of more sensitive species and groups from high use acres, and possible increased legal and illegal harvest of game, predators, and furbearers. Closure of new and some existing roads to public vehicle use would be the most important mitigation measure that could be implemented to reduce impacts.

Abandonment. Impacts to wildlife associated with revegetation and abandonment operations will be the same as those discussed under Alternative A. However, because a greater acreage of gas-related developments will be reclaimed under Alternative C, the short-term displacement of wildlife from reclamation operations will be proportionately greater under Alternative C.

4.5.3 Impacts Summary

Impacts to wildlife from direct and indirect gas development activities in the HD Mountains would be greatest under Alternative C and least under Alternative A. Impacts to deer and elk winter range are summarized in Table 4-10. Most impacts to wildlife would be those that occur onsite under all alternatives. The most adverse effects would result from indirect, onsite impacts related to operational and construction activities. Big game (elk and deer) would be the wildlife group most adversely affected because large numbers of animals would be displaced from the Study Area. Impacts to big game would be small under Alternative A. Impacts to big game would probably be low to moderate under Alternatives B or C if recommended mitigation measures are implemented. Potential impacts to threatened, endangered, and candidate species should receive a "no impact" determination. Potential impacts to the Mexican spotted owl are unknown. Ongoing 1990 surveys for Mexican spotted owls in the HD Mountains have, thus far, not detected the species.

4.5.4 Cumulative Impacts

Cumulative impact assessment is used to evaluate the influences of recent past, present, and foreseeable future human developments on the local wildlife resources. This approach examines impacts associated with a proposed project in context with all other past and future developments, whether or not they are related. It also allows the wildlife manager and land management agency to evaluate impacts in a broader perspective.
Human use of the HD Mountains Study Area has resulted in moderate amounts of habitat alterations. The most drastic direct alterations, and those affecting the largest area, have resulted from sagebrush, native grassland, and various forest habitat types cleared for agricultural uses on low elevation private lands. The effects of gas development, logging, cattle grazing, residential, and recreational activities have also had varying influences on local habitats and the wildlife that use them. FS habitat enhancement activities, pond development on private lands, and the above land use practices have benefitted some wildlife groups and adversely affected others. Unfortunately, deer and elk are the only wildlife species for which enough quantitative data exist to further discussions of impact assessment in this analysis.

The cumulative effect of past and current gas development (Table 4-8) has adversely affected elk and deer, primarily by reducing habitat effectiveness in areas proximal to roads and facilities. At 90 percent habitat effectiveness, existing losses of winter range total 5.9 percent; at 60 percent habitat effectiveness, existing losses total 21.5 percent. While herd numbers may not have been reduced by past habitat losses, reduced habitat availability may not have allowed their numbers to increase to the extent that they would have otherwise. Despite impacts associated with gas development, as well as disturbances from other human activities (e.g., logging, recreation, agricultural and residential developments, and poaching) in the HD Mountains, elk numbers have remained relatively stable over the last 10 to 15 years while deer numbers may have slightly increased.

TABLE 4-10

SUMMARY OF IMPACTS TO WILDLIFE ON NFS LANDS WITHIN THE STUDY AREA

Parameter	Alternatives		
	A	B	C
Acreage of Direct Habitat Loss	46	271	646
Acreage of Adjacent Reduced Winter Range Habitat Use[a] (Elk and Deer)	0	5,585	8,072
Acreage of Adjacent Winter Range Nonuse[b] (Elk and Deer)			
at 10%	0	559	807
at 40%[c]	0	2,234	3,229
at 70%	0	3,913	5,650
Total Acreage Lost at 40% Nonuse[c] (Elk and Deer)	46	2,505	3,875
Moderate or High Impacts to Other Wildlife Groups	No	No[d]	Probably Not[d]

[a] Includes elk and mule deer winter range, severe winter range, and winter concentration areas.
[b] Within 0.25 miles of roads, 10 to 70% nonuse based on Interagency Study Team (1977).
[c] 40% used as an average value that is probably most representative.
[d] With the implementation of recommended mitigation measures.

These trends have been extrapolated from populations from the entire Data Analysis Units (DAUs). This has been partially due to concerted management efforts and a series of mild winters. The last severe winter, during which relatively large numbers of animals died, was 1978/79. With populations at present levels, a severe winter would probably cause an increased incidence of winter mortality, road-kills, game damage claims on privately owned winter range, reduced recruitment the following spring, and a number of related effects. However, this will be a perturbation adjusting population numbers to equilibrium with available habitat remaining after the development of past gas development and other human activities in the Study Area.

Other than Amoco's proposed gas development, no other large or widespread human developments which would affect wildlife use of the area are expected to occur within the Study Area over the long-term. However, the proposed Animas-La Plata Water Project, which would be built south and southwest of Durango, will likely have minor indirect influences on wildlife use in and beyond the Study Area. Increases in local or surrounding land values related to development that would promote onsite or offsite secondary developments should be minimal. There should be small but insignificant additions to the work force encouraging home or subdivision development near the Study Area. Cattle grazing allotments and the minimal timber harvest that now occurs in the Study Area should not change appreciably and there should not be any substantial amount of additional habitats cleared for agricultural purposes. Habitats cleared for homes and small commercial developments in the surrounding area will continue at a pace slightly above current levels over the long-term. Consumptive and non-consumptive wildlife use of the area may also have an increasing trend as some additions to the work force, their family members, and others recreate in the HD Mountains. The cumulative impacts associated with human developments in and around the Study Area would be greater under implementation of Alternative C gas development, than under Alternative B. Adverse effects would result from a combination of indirect and direct impacts that are mostly confined on site.

The additional losses of big game winter range in the Study Area resulting from implementation of Alternative A, B, or C, at habitat effectiveness values of 60 percent (unmitigated), would be respectively considered moderate (7.7 percent), and large (12.1 percent) relative to those that have already occurred (Table 4-11). Cumulative winter range losses (at 60 percent habitat effectiveness) range from 22.3 to 34.5 percent for Alternatives A and C, respectively, and are considered high for all alternatives, primarily because of the high percentage (22.1) of existing losses (Tables 4-10 and 4-11). These estimates do not account for additional past reduced use from non-gas-related activities because those habitat losses and alterations could not be quantified. These past habitat losses would be additive and possibly synergistic to those resulting from gas development and may be in the range of 5 to 10 percent.

What the existing winter range habitat effectiveness values are or what they might be in the future cannot be estimated unless a detailed study is implemented to measure values based on direct or indirect evidence of elk use in the Study Area. If the present habitat effectiveness value is 60 percent, then existing impacts have resulted in a 22.1 percent reduction in available winter range. If present, habitat effectiveness is 90 percent, then losses have only amounted to 5.9 percent, a small loss. With additional 5 to 10 percent losses from non-gas-related developments in the Study Area, existing winter range losses could vary from 10.9 to 32.5 percent.

Furthermore, while the effect of existing gas development probably resulted in habitat effectiveness values closer to 90 percent, additional impacts to big game winter ranges under Alternatives B and C probably result in decreasing habitat effectiveness values, perhaps approximately 60 percent for Alternative C. Offsite enhancement of winter range values could supplement onsite efforts and compensate for lost values under all alternatives. This approach, however, may not mitigate impacts to elk and deer affected within the Study Area.

4.5.5 Mitigation Summary

A number of effective, wildlife oriented mitigation measures are an integral part of the operating plans that the proponent would be required to implement. These measures are presented in Appendixes A-1 and A-4. Additional recommended wildlife mitigation targeted toward potential, site-specific impacts in the HD Mountains are delineated below.

These supplemental measures are divided into field design, construction, and operations categories where they would be most appropriately implemented.

Field Design

- Minimize the number and length of new access roads constructed for the expansion of gas development.
- Where possible, access new wells via spur roads off the existing road system rather than separate primary access roads.
- Adopt a road system with numerous spur roads branching off each primary access road such that all roads beyond each primary access road can be closed to public access via a locked gate.

TABLE 4-11

EXISTING, POTENTIAL, AND CUMULATIVE ACREAGE
OF DIRECT AND INDIRECT IMPACTS TO
BIG GAME WINTER RANGES IN THE STUDY AREA

Alternative Reduced Use	Alternative[a]		Existing[b]		Cumulative[c]	
	Acreage	%	Acreage	%	Acreage	%
Alternative A						
Reduced Use[d] at						
90% HE	62	(<1)	2,053	(6.0)	2,115	(6.2)
60% HE	62	(<1)	7,520	(22.1)	7,582	(22.3)
30% HE	62	(<1)	12,988	(38.2)	13,050	(38.4)
Alternative B						
Reduced Use[d] at						
90% HE	902	(2.6)	2,053	(6.0)	2,955	(8.7)
60% HE	2,610	(7.7)	7,520	(22.1)	10,130	(29.8)
30% HE	4,322	(12.7)	12,988	(38.2)	17,310	(50.9)
Alternative C						
Reduced Use[d] at						
90% HE	1,618	(4.7)	2,053	(6.0)	3,671	(10.8)
60% HE	4,132	(12.1)	7,520	(22.1)	11,652	(34.5)
30% HE	6,644	(19.5)	12,988	(38.2)	19,632	(57.7)

[a] Totals from Table 4.9
[b] Totals from Table 4.8
[c] Does not include reduced use from non-gas related activities which could not be quantified; total winter range acreage in the Study Area is 34,009 acres
[d] Based on Interagency Study Team (1977)

- Where possible, select noncritical wildlife habitats over critical or important habitats (e.g., big game winter range, turkey roosts, and riparian corridors) for siting roads, pipelines, and wellpads. Longer roads through noncritical habitats are generally preferred over shorter routes through critical habitats.

- Minimize the number of stream crossings.

- Attempt to maintain a minimum 100-foot zone of undisturbed vegetation between roads and streams to trap erosion, reduce sedimentation, and maintain water quality.

- Following initial surveys to stake ROW alignment and well siting, notify the FS if any prairie dog towns are to be disturbed. The intended disturbance of prairie dog towns on federal or state lands would likely require those towns to be "cleared" for black-footed ferrets. It would be much simpler to avoid any towns.

- Continue to survey for the Mexican spotted owl in suitable habitats until a determination is made about their listing.

Construction

- Prohibit construction in critical wildlife habitats during critical seasons. For example, construct roads and drill wells in big game winter range during summer. Restrict drilling in or within 1/4 mile of big game winter ranges from November 30 to April 30, with flexible specific dates to be determined semi-annually (fall and spring) via communications between Amoco, FS, and CDOW, based on seasonal conditions and big game habitats use.

- Reduce the area and duration of disturbance, such as minimizing pad size, and revegetating pad slopes, road shoulders, and pipeline corridors with vegetation beneficial to wildlife.

- Minimize fencing and install fencing that reduces wildlife mortality and restricts wildlife movements while meeting gas company needs. For example, a 38-inch-high top strand with a 12-inch kickspace below is adequate to restrict cattle, yet permits easier wildlife movements.

- Prohibit employees and contractors from bringing dogs onsite or carrying firearms.

Operation

- Close all new roads, including spur roads off existing roads, to public access with locked gates as far down on the road system (i.e., as close to the FS boundary) as possible. Closing gravel roads (through big game winter range) that are open to the public can reduce adjacent zones of disturbance and increase habitat effectiveness. Gate locations should be located to use natural topographic features, vegetation, or supplemental barriers to restrict the public from driving around the gates. After seasonal wildlife impacts associated with a new or expanded road system are evaluated, some roads may be seasonally opened to the public during noncritical wildlife periods to better meet recreational and game management goals. Decisions would be made after consultation and agreement among Amoco, FS, and CDOW.

- Seasonally close some existing FS access roads (e.g., Spring and Sauls Creek Road) to public vehicle use between November 30 and April 30 (Spring Creek Road closure December 26 through April 30) to reduce poaching and harassment of big game on winter ranges. Signed, locked gates should be installed as close to the FS boundary as possible as delineated above. Sign language might consist of "Road closed to public vehicle use between November 30 and April 30 to protect big game on winter ranges."

- Equip all new wells with telemetry to reduce monitoring frequency from daily visits to 2 to 3 visits per week, if possible.

- Schedule maintenance activities to occur between 1000 to 1400 hours at facilities in important wildlife habitats (e.g., big game winter range) during critical seasons and at facilities that must be accessed by roads through sensitive habitats.

- Prohibit employees and contractors from bringing dogs and firearms to work and prohibit nonauthorized use behind locked gates.

- Continue to implement periodic employee/contractor wildlife awareness programs covering seasonal wildlife requirements and sensitivities, how disturbances affect wildlife, and ways personnel can reduce disturbances.

- Maintain open communications between Amoco, FS, and CDOW to adjust or refine operations in response to changes in seasonal wildlife use patterns.

- Enhance existing big game winter range in suitable undisturbed portions of the Study Area to reduce loss of FS winter range. Use habitat manipulation to convert adjacent habitats in the Study Area into winter foraging areas. The HABCAP model will be used to evaluate the effectiveness of the manipulations.

- Reduce or eliminate domestic livestock grazing on HD land which overlap elk and deer winter range to increase forage availability.

4.6 VISUAL RESOURCES

4.6.1 Introduction

The approach used to assess impacts to visual resources is based on general FS guideline potential for applying Visual Absorption Capability (VAC) to Visual Quality Objectives (VQOs) for identifying significant visual contrast. VAC is an estimate of the relative ability of a landscape to withstand land manipulation activities without affecting its visual character or integrity. It is used to judge the relative capability of the landscape to absorb visual change and meet the established VQO.

The degree to which the project may adversely affect the aesthetic quality of the landscape depends upon the amount of visual and aesthetic contrast that is created by the project in relation to the existing landscape character. The amount of contrast between the proposed action and the existing landscape character can be measured by separating the landscape into its major features (landform, vegetation, and structures), and then predicting the magnitude of change in contrasting each of the basic visual elements (form, line, color, and texture) to each of the features.

Landscape management is based on VQO levels or the synthesis of scenic quality, visual sensitivity, and distance zones. The measure of the adverse response of the visual and aesthetic resources is defined as visual contrast.

Visual resource sensitivity is evaluated based upon criteria and methodology established by the FS. Two issues are important in determining the level of sensitivity: (1) the type and extent of actual physical contrast, and

(2) the level of visibility of a corridor segment or facility with consideration given to the landscape's VQO VAC to absorb or hide facilities or corridors. Impact to visual resources is considered significant if the construction and operation of the proposed action would adversely affect: (1) the quality or scenic variety of any scenic resource; (2) any scenic resource having rare or unique values; (3) the view from, or the visual setting of, any designated or planned park, wilderness, natural area, or other visually sensitive land use; (4) the view from, or the visual setting of, any major travel route; and/or (5) the view from, or the visual setting of, any established, designated, or planned recreation, education, preservation, or scientific facility, use area, activity, and view point of vista. Effects are determined by comparing the net level of estimated contrast with the visual management guidelines defined for the given VQO class.

Levels of sensitivity would be based upon VQO and VAC classification of land crossed by each alternative. Potentially high impacts would occur in Retention (R) land of low to moderate VAC; moderate impacts would occur on Partial Retention (PR) land of moderate VAC; low impacts would occur on Modification (M) land of moderate to high VAC; and minimal impacts to land seldom seen. Figure 4-8 displays areas of high sensitivity for visual resources.

Major viewpoints and viewing areas in the Study Area include the major roads of U.S. 160, State Route 151, La Plata County (LPC) 521 (Buck Highway), and LPC 516 (Rainbow Highway); vista point of Chimney Rock; nearby residences; and the community of Bayfield.

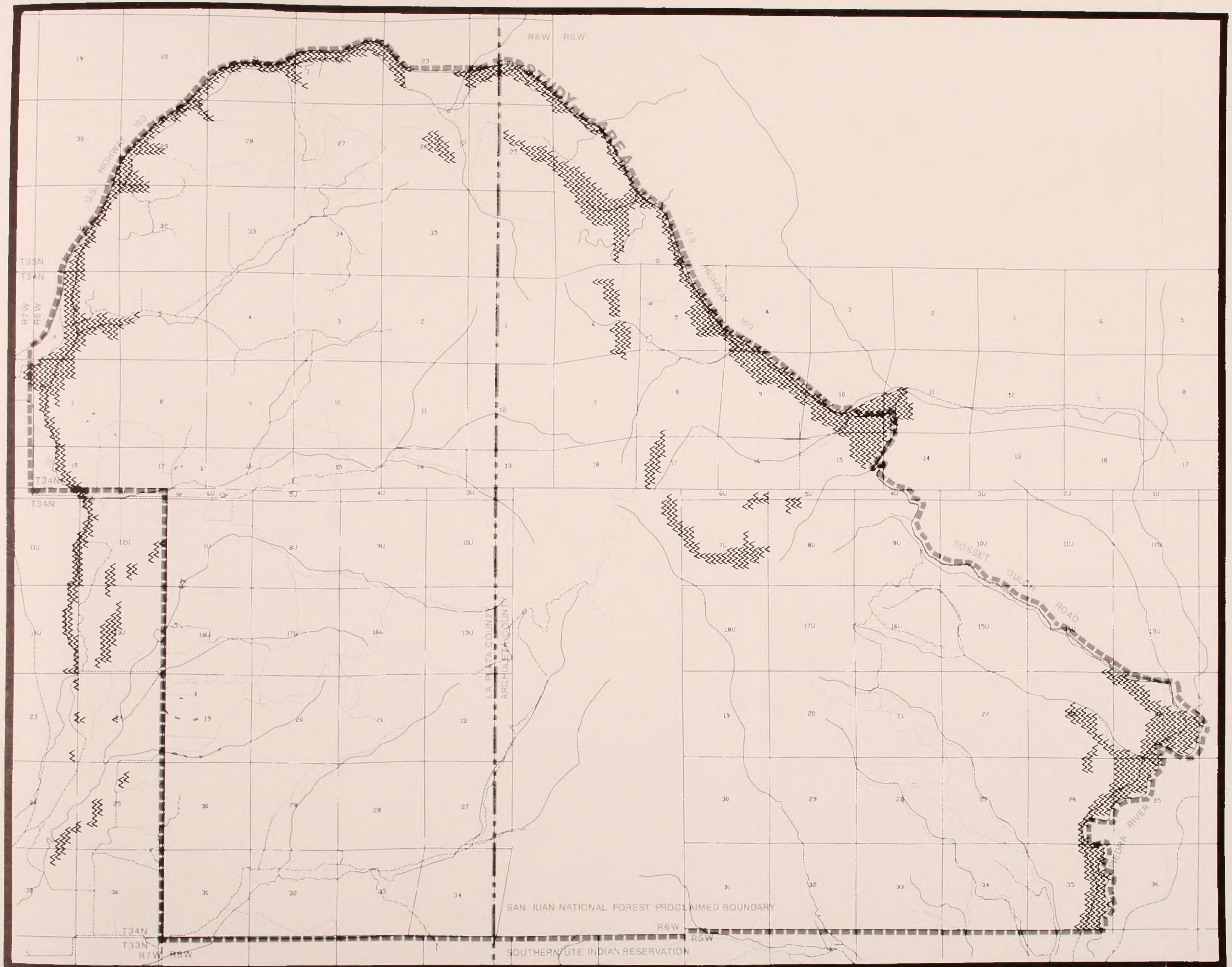
4.6.2 Direct and Indirect Impacts

4.6.2.1 Alternative A - No Action

Construction. Short-term adverse impacts would be generated by new flowline construction. Due to the short duration of visual disturbance, low adverse impacts were identified. Indirect short-term adverse visual effects on nearby residences of truck traffic and dust would be created. These are further described under Land Use, Section 4.8.2.

No additional adverse impacts to visual resources were identified on existing facilities on NFS lands.

Operations. No additional impacts would be expected.



VISUAL RESOURCES SENSITIVITY

HIGH SENSITIVITY AREA INCLUDES RETENTION AREAS OF LOW VAC AND HIGHLY VISIBLE PARTIAL RETENTION AREAS

< AREA OF HIGH SENSITIVITY

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 4-8

Abandonment. Long-term positive effects would be generated by improving scenic quality. However, visual disturbances from construction in form, texture, and color to landforms and vegetation would remain for an undetermined period of time after abandonment. These adverse impacts would not be significant. Short-term disturbance of truck traffic and dust would occur. These short-term adverse effects would be minimal.

4.6.2.2 Alternative B - Proposed Action

Construction. Long-term direct adverse visual impacts would be expected for two well sites on private lands located along the Piedra River (Figure 2-2). These two locations are generally characterized as Retention (R) VQO and VAC (Figures 3-11 and 3-12). The visual contrast would consist of noticeable changes of form, texture, and color of landforms and surrounding vegetation. The physical contrast would consist of cuts and fills and removal of vegetation. Short-term indirect adverse effects on nearby residences would occur and are described under Land Use, Section 4.8.2. For the remaining proposed wells, long-term visual impacts would be moderate to low as they have an acceptable degree of alteration in terms of visual contrast with the surrounding natural landscape.

Although some "broken" line contrast to vegetation may result from access road/flowline ROW, these impacts would be low to moderate. No other significant direct adverse visual impacts were identified. Land Use, Section 4.8.2, describes indirect adverse visual effects that oil and gas traffic would have on nearby residences.

Low adverse impacts were identified for the Pargin Mountain compressor station.

Operations. The location of adverse impacts identified under construction for the two wellsites would continue to occur during operation. Although some line contrast to vegetation would likely occur, no ROWs creating adverse impacts were identified.

Abandonment. Visual impacts associated with Alternative B are similar to those associated with Alternative A, subsection 4.6.2.1.

4.6.2.3 Alternative C - Current Direction

Construction. A total of 16 well sites (five private, 11 FS) could potentially create long-term significant adverse impact (Figures 2-7 and 4-8). The types of impacts associated with Alternative C would be similar to, but more wide spread, than those described for Alternative B (Section 4.6.2.2). The density of new access roads located

in the northern portion of the Study Area, connecting to U.S. Highway 160, and new access roads identified in the eastern portion of the Study Area, connecting to South Fossett Gulch road, would create significant color contrast which would draw visual attention. Physical contrast would consist of cuts and fills and removal of vegetation.

Operations. The impacts of visual disturbance identified under the construction phase would remain during long-term operation.

Abandonment. The impacts associated with the other project alternatives would be similar for Alternative C. Visual scars (color, texture, and line contrast to vegetation) created during construction would likely still remain evident for years after abandonment.

4.6.3 Impacts Summary

Table 4-12 displays potential acres of impact to visual resources by each alternative. Alternative C would cause the most wide-spread area of direct visual impacts; Alternative B would cause impacts to a lesser extent. For Alternative C, the visual impacts from nine wellsites may potentially be observed from US Highway 160; none of the proposed well sites for Alternative B would be visible from U.S. Highway 160. Visual contrast for wellsites would include change in form, color, and texture to surrounding landform and vegetation, introduction of line texture to surrounding landform and vegetation, and introduction of line 2 texture and color contrast to corridors. Evidence of visual disturbance would remain for an undetermined period of time after abandonment for all the project alternatives.

4.6.4 Cumulative Impacts

For Alternative C, long-term adverse visual effects would occur for the life of the project and remain for some time after abandonment. The inherent visual character and scenic quality of the landscape, particularly as viewed in the western and northern portions of the Study Area, is undergoing active modification. Although the introduction of pump jacks and other oil and gas facilities are generally prescribed for short-term duration, the overall visual character of the landscape (private and public land) is being culturally modified from a rural, agriculture, and pastoral character to a widely spaced light industrial type landscape. These modifications are being generated primarily by oil and gas development located, for the most part, on adjacent private lands.

TABLE 4-12

ACRES OF IMPACT TO AREAS OF HIGH SENSITIVITY FOR VISUAL RESOURCES

	Alternatives						
	A	B			C		
Land Ownership	Flowlines ROW System	Windows	50-foot Wide ROW System	600-foot Wide Corridor System	Windows	50-foot Wide ROW System	600-foot Wide Corridor System
NFS	1.0	0	0	0	204	2.3	37.5
Private	6.8	42.7	0	0	97	0	0.3
State	0	0	0	0	0	0	0

4.6.5 Mitigation Summary

For reducing adverse visual contrast, there are three generic types of mitigation techniques: (1) strategic location, (2) minimization of disturbance, and (3) facility design with consideration given to repeating or borrowing from the basic landscape elements (form, line, color, texture). Mitigation measures which address each of the three types are included in Appendixes A-1 and A-4. The appropriate selection of additional mitigation recommendations listed below will effectively reduce visual contrasts for most types of project facilities.

Strategic Location

- Locate facilities away from prominent topographic features.

- If possible, locations should avoid populated areas, parks, scenic areas, hilltops, and natural or man-made structures. For pipeline and other linear facilities, avoid crossing crests of hills.

- Where possible, facilities should be located where they may be naturally or artificially screened. Ridgelines should be avoided unless adequate vegetation or topographic screening is available.

- For sloping terrain, a multiple-level, terraced facility plan should be considered to minimize excavation and provide a facility that will blend effectively. Near travel routes, facilities should be located partway up slopes to provide a background of topography and/or natural cover where possible. Screen these facilities from highways and other areas of public view to the maximum extent possible with natural vegetation and terrain.

- Where placement of a facility is necessary in a hilltop area, consider locations on the slopes or brow of a hill to allow minimum silhouette or skylining.

- Facilities in general should be strategically placed to make maximum use of existing topography and vegetation for screening. Use the edge effect for facility placement along natural vegetation breaks.

- Facilities should be located at the base of slopes when feasible to provide a background of topography and/or natural cover.

Minimization of Disturbance

- During construction, clearing of land for project facilities or structures should create curvilinear boundaries instead of straight lines to minimize disturbance of the landscape. Grading should be done in a manner which will minimize erosion and conform to the natural topography (FS 1977).

- The clearing of trees and vegetation for the project facilities should be limited to the minimum area required. Feather and thin edges of vegetation.

- To the maximum extent possible, all foliage adjacent to the site should remain undisturbed to provide maximum screening of the installation.

- Brush or small trees cleared and not otherwise disposed where designated may be spread in a way to provide cover habitat for small mammals, reptiles, and birds. Woody materials should be randomly placed, particularly in downslope fill areas, to conform to adjacent vegetation patterns.

- All nonmerchantable timber and other vegetation material cut without value should be mechanically chipped and spread in a manner that will aid seedling establishment and soil stabilization.

- Soil which has been excavated during construction and not used should be evenly backfilled into the cleared area or removed from the site. The soil should be graded to conform with the terrain and the adjacent land.

- Dumping of excess material on downhill slopes should be minimized.

- Replacement of earth adjacent to water crossings should be at slopes less than the normal angle of repose for the soil type involved.

- Cut and fill slopes should be rounded to break sharp unnatural edges formed at the contact point between the constant-pitch out-slope and the rounded natural landform..

- To reduce the short-term impacts associated with road construction, it is recommended that steps be taken to minimize fugitive dust (e.g., water roads, gravel, 15 mph speed limit).

- During construction, care should be taken to protect all existing vegetative cover, trees and shrubs in particular at the edge of the right-of-way. Cut and fill sections on all access roads should be revegetated with indigenous species or adapted species that match native plant community phenology. Planting should occur at the earliest suitable planting date. All post-construction debris should be removed immediately after construction.

Facility Design

- In general, when practicable, the use of low-profile concepts and simplified structures will enhance the overall appearance of the facility. Structures should be single story and of minimum size to satisfy present and future functional requirements.

- Cut and fill slopes should be designed to achieve maximum compatibility with the surrounding natural topography. Access roads should be aligned to follow existing grades to minimize cuts and fills.

- Access roads should be provided with side drainage ditches and traverse culverts to prevent soil or road erosion.

- Revegetation efforts should consider creative landscaping practices in highly visible or sensitive areas to enhance the appearance of project facility installation. Consideration should be given to:

  - Mulching cleared cut and fill areas
  - Controlling planting times
  - Furrowing slopes
  - Planting holes on cut/fill slopes
  - Choosing native plant species
  - Stockpiling and reusing topsoil
  - Fertilizing, mulching, and watering vegetation
  - Adding mulch, hydromulch, or topsoil
  - Soil retaining matting
  - Shaping cuts and fills to appear as natural forms
  - Cutting rock areas so forms are irregular
  - Designing to take advantage of natural screens (i.e. vegetation, landforms)

- Grass seeding cuts and fills

- Project signs, ground cover, etc., should be compatible with their surroundings.

- Exterior lighting for project facilities should be adequate for work and for protection of the facilities from sabotage and malicious mischief, and should be acceptable to the landowner.

- Color (hue) of project facilities is most effective within 1,000 feet (Johnson et al. 1970). Beyond that point, the hue becomes indistinguishable and only the value of the color can be expected to have any appreciable effect. When viewed from the shaded side, a facility structure appears as a dark silhouette and generally its color is indistinguishable. Consideration should be given to coloring of facilities to blend with the landscape. This is particularly significant in or near areas of high scenic value. The colors selected for project facilities and structures should be based on the following considerations (Robinette 1973):

  - The colors should be uniform and noncontrasting, to blend with the immediate natural environment. The warmest color tones are appropriate for natural settings.

  - Exposed concrete at well sites should be painted to match soil color.

  - Colors should be selected on the basis of their ability to blend with the land and not the sky.

  - Colors that are similar to adjacent colors are most successful in adapting to their environment.

  - Paint project facilities somewhat darker than the adjacent landscape to compensate for the effects of shade and shadow.

  - Select paint finishes with low levels of reflectivity (i.e., flat or semi-gloss).

  - Colors similar to those in the Munsell Soil Color Coding System and displayed on the Standard Environmental Color Chart, prepared by Rocky Mountain Five-State Interagency Committee, should be considered for all project facilities.

4.6.6 Unavoidable Adverse Impacts

Visual contrasts to existing vegetation based on color, texture, and line would be created by construction and operation of project facilities. These visual impacts would likely remain evident for an extended period after abandonment.

4.7 CULTURAL RESOURCES

4.7.1 Introduction

The construction, operation, and abandonment of well pads, well site facilities, access roads and flowlines, and additional facilities including compressor stations, may impact significant cultural resources. Significant resources are defined as archaeological and historic sites listed in or eligible for listing in the National Register of Historic Places. Known sites with an undetermined status are protected until eligibility can be determined. Sites or localities important to American Indian groups may also be considered significant, although none have been identified in the Study Area at this time.

Impacts to significant resources from the above listed activities are usually adverse. Current studies are investigating potential beneficial impacts to sites; however, there is not enough evidence to use in this study.

Adverse impacts can be direct or secondary. Direct impacts are usually physical and directly related to construction or operation activities. Secondary impacts can also directly affect sites, but they are not caused by construction or operation activities. Vandalism and artifact collecting are secondary impacts that may be augmented by better and more access roads in an area. Erosion due to cleared land may create long-term secondary impacts to sites.

Cumulative impacts are the sum of direct and secondary impacts for each alternative. For this study, cumulative impacts are examined for the foreseeable future and only for the three alternatives of this project. Therefore, cumulative impacts for Alternative C include all direct and secondary impacts analyzed for all three alternatives. Since there are no other major actions planned in this area by the FS in the foreseeable future (e.g., timber sales), impacts resulting from other actions are not included.

The Advisory Council on Historic Preservation has set out the procedures to be followed to determine the effects a project may have on significant cultural resources and how to mitigate that effect if it is adverse.

These regulations (36 CFR 800) mandate the procedure the FS will follow to take into account all project effects (direct and secondary) on significant resources. Since this process can be lengthy, with many participants including the FS, State Historic Preservation Officer, Advisory Council, project proponent, and other interested parties, the FS may pursue executing a Memorandum of Agreement (MOA) among all these parties. The purpose of a MOA will be to set out the procedures for identification, avoidance and protection of significant resources, and mitigation of adverse effects, as appropriate. The MOA would incorporate elements of this EIS such as mitigation and site protection measures outlined in this section.

Since archaeological sites are frequently determined eligible to the National Register under criterion (d) of 36 CFR 60.4 (see Section 3.7), direct adverse effects can often be mitigated with the implementation of a data recovery program if avoidance is not feasible. The procedures for implementing such a program, including steps for review and approval by the appropriate agencies would be included in a MOA.

The regulations at 36 CFR 800 are written in such in a fashion that the public and project proponent can participate in the consultation process, although the Forest Service is the agency responsible for ensuring the terms of the MOA are carried out. This procedure ensures maximum protection for significant resources while allowing the proponent to proceed with the project in an orderly fashion.

The effects of a project on significant resources are considered adverse when the integrity of the site is diminished. These effects may include:

A. Physical destruction, damage, or alteration of all or part of the property;

B. Isolation of the property from or alteration of the character of the property's setting when the character contributes to the property's qualification for the National Register;

C. Introduction of visual, audible, or atmospheric elements that are out of character with the property or alter its setting;

D. Neglect of a property resulting in its deterioration or destruction; and

E. Transfer, lease, or sale of the property (36 CFR 800.9).

For most archaeological sites, the first effect (A) is the one of greatest concern. The other effects may not be a consideration, as they would not affect the elements of a site that caused it to be considered significant. For example, effect "C" would not impact the scientific information content of a site but would be of consideration if the site was being developed for the public enjoyment or as an educational facility.

Many of the effects to significant cultural resources can be mitigated. While the plans for mitigation are site-specific, there are standard procedures to be followed to develop these plans. These plans could be included in a MOA and require:

A. An intensive Class III survey of the construction area including well sites, compressor stations, access roads, and pipeline corridors;

B. An evaluation of identified resources for eligibility for the National Register of Historic Places, using the criteria at 36 CFR 60.4, in consultation with the State Historic Preservation Officer (SHPO);

C. Determinations of effect on eligible properties in consultation with the SHPO Advisory Council, and the San Juan National Forest Archaeologist;

D. Determinations of effect on nominated properties in consultation with the San Juan National Forest Archaeologist, SHPO, Advisory Council; and

E. Implementation of prudent and feasible measures to avoid, reduce, or mitigate adverse effects.

Since much of the Study Area is uninventoried, the first step is an intensive survey by professional, permitted archaeologists of all areas proposed for direct impact. All located resources, and those previously recorded in impact areas, will be evaluated for their eligibility to the National Register. General criteria used in this evaluation include:

A. Condition (integrity) of the site;

B. Cultural affiliation;

C. Date of occupation or construction;

D. Number of cultural/temporal components;

E. Site type (i.e., habitation, campsite, etc.);

F. Availability of historical records for documenting historical sites; and

G. Ability of the site to contribute significant data to our understanding of history or prehistory.

The evaluations and determinations of eligibility are made by the Forest Service (in consultation with the SHPO) based upon recommendations of professional archaeologists.

After the evaluation of the resource, a plan best suited for mitigating impacts to the individual resource or resources will be formulated in consultation with the appropriate agencies and implemented. The mitigation plan as designed for the project consists of three alternatives: avoidance, protection, or data collection and analysis. A brief explanation of each alternative follows:

A. Avoidance of significant cultural resources consists of moving or modification of the proposed project. Avoidance is the emphasized alternative. Wells can be moved within the 40-acre windows and flowlines and roads may be moved within the 600-foot wide study corridor. In the event avoidance is not practical, procedures have been developed to mitigate related impacts.

B. Protection of a site can include nomination to the National Register, erection of physical barriers or marking, or the monitoring of construction activities by a professional, permitted archaeologist. Long-term protection may include increased observation by Forest Service personnel or interested local citizens. Locked gates may be erected to prevent unauthorized traffic on certain roads.

C. Data collection and analysis is utilized at sites determined eligible under criterion (d) of 36 CFR 60.4, if avoidance or protection measures would not feasibly protect the site from impact. Record and literature searches, including analyses of collections or data from relevant nearby site, may be undertaken. Limited test excavations may be required to determine the significance of the site. The most detailed means of data collection for prehistoric sites include controlled excavation and analysis.

Data collection at historic sites may include records searches, personal interviews, and/or recording structures to the standards of the Historic American Building Survey (HABS) and the Historic American Engineering Record (HAER).

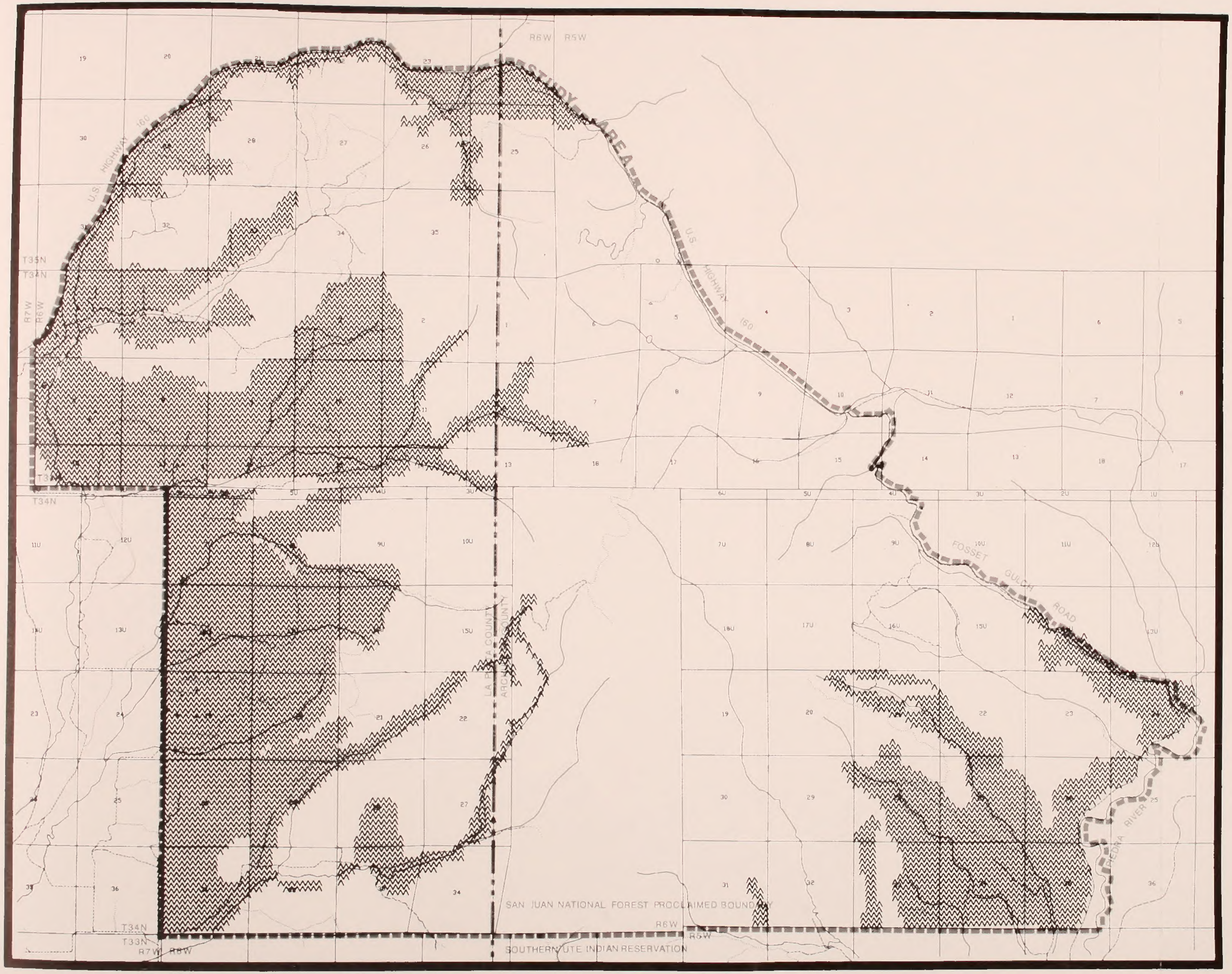
Development of a data recovery plan to mitigate direct adverse effects involves consultation and coordination among the signatories of a MOA. The project's overall efforts are taken into consideration, as well as impacts to individual sites. A research plan is formulated using the latest research directions and assuring the techniques for data recovery and analysis are available and reasonable. Professional standards and guidelines are utilized and input is solicited from several sources. Since site excavation is a physically destructive means of mitigating impact, it is done only under strict guidance after a comprehensive review process. It must be demonstrated that the information is important and clearly recoverable.

Mitigation of secondary impacts is not as straight forward, as it requires some speculation. For instance, it has been assumed for years that improving access into areas containing sensitive archaeological sites automatically results in an increase in vandalism and unauthorized artifact collection (pot hunting). This is a very real threat to sites, as it often destroys the potential for recovery of significant information regarding the past history of our country. It can also destroy the character of the site and make it useless for future public enjoyment or education. However, there is new evidence suggesting that easy access to sites, in the form of graveled and graded roads, may actually inhibit the serious pot hunters and site vandals who prefer to work unobserved. This does not mean roads should be built to protect sites; just that impact to sites may be reduced in areas with improved roads versus two-tracks or 4-wheel drive roads.

The best protection, however, is still no roads at all. For this study it was not assumed that improved access roads would decrease illegal artifact collection.

Mitigation of secondary impacts could include restricting public access in some areas, increased patrols by the Forest Service, increased on-site presence by local interested groups or citizens, archaeological monitoring during construction, site review at scheduled intervals, education of work crews, public education, and data recovery. Requirements for mitigation of secondary impacts could be included in a MOA.

Archaeological sites determined eligible for the National Register are usually eligible under criterion (d) of 36 CFR 60.4 (see Section 3.7) for the scientific information they may contain. Direct impacts to these types of sites are usually mitigated by data recovery if they cannot be avoided. Under the regulations at 36 CFR 800.9 (c), a project would be considered to have no adverse effect to these sites if the data could be substantially



CULTURAL RESOURCES SENSITIVITY

HIGH SENSITIVITY AREAS INCLUDE AREAS OF EITHER KNOWN OR PREDICTED HIGH SITE DENSITY

Λ AREA OF HIGH SENSITIVITY

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE **4-9**

preserved through professional recovery and analysis. In the following sections, when reference is made to no sites being adversely affected, there is an assumption that data recovery may take place at eligible sites. This "no adverse effect" determination does not apply to sites that are listed on the National Register or determined eligible under criteria (a), (b), or (c) of 36 CFR 60.4.

For the following analysis, the Study Area was divided into areas of probable high site frequency defined as more than 7.5 sites per square mile and probable low site frequency defined as less than 7.5 sites per square mile. Since only about 21 percent of the Study Area has been intensively surveyed, these projections are based on the locations of known sites and their relationship to a number of environmental factors. It should be stressed that all locations of proposed disturbance will be intensively surveyed, regardless of their location in a high or low site frequency area. For comparison purposes, approximately 32 percent of the Study Area has been projected as a high site frequency area (Figure 4-9). This includes surveyed and unsurveyed areas.

4.7.2 Direct and Secondary Impacts

4.7.2.1 Alternative A - No Action

Alternative A would involve the construction of 19 miles of flowlines on NFS lands. The proposed flowline routes will consist of a 20-foot wide ROW network and will involve disturbance of approximately 30 acres of high sensitivity area and 16 acres of low sensitivity area. There are approximately 6.5 miles of flowline routes planned on private lands, involving crossing 10 acres of high sensitivity areas and 6 acres of low sensitivity areas.

Construction. The proposed flowlines that are located in the high sensitivity areas have a good likelihood of impacting significant cultural resources. All flowlines would be surveyed prior to construction. If eligible sites are located and avoidance is not feasible, a mitigation plan would be implemented. Other activities may include construction monitoring by a permitted archaeologist. Any subsurface resources located would be evaluated according to procedures set forth in a MOA. Mitigation by data recovery may be required.

The introduction of construction crews into high sensitivity areas may result in secondary impacts of significant resources in the form of vandalism or artifact collection.

Operations. No direct impacts to significant resources would occur from normal operations. Emergency repairs requiring clearing or trenching might directly impact significant resources only if they had not been

discovered prior to construction, or if operations were required outside the previously surveyed ROW. There may be secondary impacts due to increased ease of access by conventional vehicles into the high sensitivity areas.

Existing well field facilities would have no direct impacts on cultural resources since sites were avoided or protected or impacts mitigated prior to construction of facilities. New access into undeveloped areas and increased ease of access into other areas could encourage vandalism to cultural resources which constitutes an adverse secondary impact.

Abandonment. Abandonment of facilities would have no adverse direct impacts on cultural resources provided that ground disturbing activities are confined to areas previously examined and cleared for initial construction.

4.7.2.2 Alternative B - Proposed Action

Alternative B includes construction of 28 well pads on NFS lands with access roads and flowlines. Each well pad will disturb approximately three acres, however, the exact location within the windows is known for only five of these wells. Since the remaining wells could be located anywhere within the windows, a much larger area was examined.

Approximately 583 acres (52 percent) of NFS lands covered by the 28 windows are in a high sensitivity area. The low sensitivity areas covers approximately 529 acres or 48 percent. Each window covers approximately 40 acres, although this varies somewhat. On private lands there are six well windows, with approximately 151 acres in high sensitivity areas and 72 acres low in sensitivity areas. Only seven windows are located entirely in low sensitivity areas and all are on NFS lands.

Approximately 23 miles of access roads and parallel flowlines will be constructed on NFS lands. Total right of-way for the combined disturbance will be 50 feet, totaling 141 acres. Forty percent (56 acres) will cross high sensitivity areas and 60 percent (85 acres) will traverse the low sensitivity areas. A 600-foot wide corridor along the proposed flowline and access road routes was examined for the possibility of moving the ROW up to 275 feet either side of centerline. There is essentially no difference between the proposed 50-foot wide ROW and the 600-foot wide corridor, with 41 percent of the corridor running through high sensitivity areas and 59 percent crossing the low sensitivity area. No comparisons can be made on private lands, as the routes have not yet been identified.

Construction. The proposed project features would disturb approximately 271 acres of new ground on the Forest and include well sites, access roads, and flowlines. All areas proposed for direct disturbance will be surveyed for cultural resources prior to construction activities.

Cultural resources determined eligible for the National Register may be impacted by construction, although the preferred alternative is to avoid impact by relocation of project features. Due to the high site density in some areas and the site size, it is unlikely all eligible resources will be avoided. For instance, one well window is located on a site approaching 160 acres in size. Mitigation of impacts will be required at any of these locations where avoidance is not possible.

Five of the well windows and associated access roads and flowlines are located in the Spring Creek Archaeological District. This is an extremely sensitive area containing numerous sensitive sites and a high probability of additional buried sites. It is unlikely that construction activities will be able to avoid all significant resources. Plans for mitigating both direct and secondary impacts will require careful formulation to protect the values inherent in this district.

There may be some locations where it is unclear, even after an intensive survey, if significant cultural resources will be impacted by construction activities. This may be due to the vegetation cover or the subsurface nature of the resource. In these cases, it may be necessary for construction activities to be monitored by a professional, permitted archaeologist. This decision would be made in accordance with the stipulations outlined in a MOA.

With the implementation of avoidance and mitigation measures, the construction of well pads, access roads, and flowlines should have no adverse effect on significant cultural resources. It is possible that previously unknown, buried resources may be affected, even with a monitoring program. Methods for mitigating this potential situation are included in the Mitigation Summary, Section 4.7.5.

Secondary impacts to significant resources could increase during construction activities due to improved access and a greater human population in the area. These impacts are difficult to quantify, although some such as the Spring Creek Archaeological District may be especially vulnerable. Mitigation measures for lessening this impact have been discussed and are summarized in Section 4.7.5.

Operations. It is unlikely significant resources would be directly impacted by normal operations. Secondary impacts to significant resources could increase due to erosion, increased human traffic, and better access to previously inaccessible areas. Methods for mitigating this impact have been discussed.

Abandonment. Abandonment of facilities should have no impact to significant resources providing ground-disturbing activities are confined to previously surveyed and cleared areas. There may even be beneficial effects if access roads are closed and reclaimed and access to sensitive areas is denied.

4.7.2.3 Alternative C - Current Direction

Alternative C would include the construction of a total of 95 wells on NFS lands with access roads and flowlines. This includes the 28 wells discussed in Alternative B. As in Alternative B, each well pad would disturb three acres; however, the exact locations within the windows are not yet determined for 90 of the 95 proposed wells.

The windows include approximately 939 acres of high sensitivity NFS lands (26 percent) and 2,620 acres (74 percent) on low sensitivity land. This sharp decrease in the percent of high sensitivity acreage included in the windows compared to that in Alternative B (52 percent) is due to more windows being located at higher elevations, on steeper slopes, and further from water. There are 20 windows located on private lands, with 63 percent (372 acres) of the area included in high sensitivity areas, and 37 percent (587 acres) included in the low sensitivity areas. One window is located on state lands; it is in a low sensitivity area. Many of the windows do not include 40 acres, due to boundary restrictions.

Approximately 52 miles (315 acres) of access roads and parallel flowlines will be constructed on NFS lands. Thirty-one percent (99 acres) cross high sensitivity areas and 69 percent (216 acres) traverses low sensitivity areas. Comparing the 600-foot wide corridor with proposed roads and flowlines yields exactly the same percentage (31 percent) of high sensitivity area crossed. No comparisons can be made on private lands, as the routes have not yet been identified.

Construction. The proposed alternative would disturb approximately 646 acres of NFS lands. All well pads, access roads, and flowlines would be surveyed for cultural resources prior to construction activities.

Construction impacts and mitigation procedures would be the same as those outlined in Alternative B, Section 4.7.2.2. Although the percentage of high sensitivity area is lower than that of Alternative B, the area is still

substantial. For example, there are an additional four windows and associated access roads and flowlines located in the Spring Creek Archeological District for a total of nine wells. Extensive data collection in the District is almost assured.

The addition of more construction crews increases the chances for secondary impact due to vandalism and artifact collecting. Means to mitigate this impact have been discussed and are summarized in Section 4.7.5.

Operations. It is unlikely significant resources would be directly impacted by normal operations. Secondary impacts to significant resources could increase due to erosion, increased human traffic, and better access to previously inaccessible areas. Mitigation methods have been discussed.

Abandonment. Abandonment of facilities should have no impact to significant resources providing ground-disturbing activities are confined to previously surveyed areas. There may even be beneficial effects if access roads are closed and reclaimed and access to sensitive areas is denied.

4.7.3 Impacts Summary

It is probable that there will be impacts to significant cultural resources from construction of any of the alternatives. The greatest impacts, both direct and secondary, can be expected under Alternative C. However, with the implementation of the mitigation program, there should be no adverse project effects to significant cultural resources.

4.7.4 Cumulative Impacts

Cumulatively, if Alternative C is constructed, as many as 117 acres of high sensitivity areas on NFS lands could be impacted by well-pad construction. Another 99 acres in high sensitivity areas would be impacted by access road and flowline construction. Because surveys have not been completed and consultation among the appropriate agencies not yet effected, it is not known how many sites will be impacted.

There are no Forest Service actions in the foreseeable future that would add appreciably to these impacts. No other actions or impacts were analyzed.

4.7.5 Mitigation Summary

Several measures can be taken to mitigate direct and secondary impacts. For direct impacts, site avoidance is preferred, followed by site protection and data collection and analysis. It is anticipated all of these measures will be necessary, especially for Alternatives B and C.

Measures to be undertaken to mitigate secondary impacts include restricting public access, increased Forest Service patrols, increased on-site presence by local interested groups or citizens, archaeological monitoring during construction, site review at scheduled intervals, education of work crews, public education, and data recovery. It is anticipated a combination of these measures may be necessary, depending upon the site-specific situation. A MOA could include stipulations for mitigating both direct and secondary impact. Site-specific details could be worked out among the MOA participants.

Although intensive identification and mitigation measures will be undertaken, there is always a chance of encountering previously unknown resources. If this situation occurs, the proponent's crews will immediately cease operations in the area of the discovery. The District Ranger will be notified and the resource will be evaluated for significance and National Register Eligibility. If determined necessary, mitigation measures will be carried out prior to resumption of construction or operation activities. Stipulations concerning discoveries, including agency response time, could be included in a MOA.

4.7.6 Unavoidable Adverse Impacts

Although the majority of the adverse effects will be mitigated by a variety of measures, there may be some unavoidable adverse impacts. This would be especially true if mitigation by data recovery is undertaken. The commitment of a resource to a destructive mitigation measure (excavation) forecloses other options; it is an irretrievable commitment of a non-renewable resource. The site cannot be used in the future or for educational purposes as an archaeological interpretive park. This constitutes an unavoidable impact to certain public use values, and may be of special concern in the Spring Creek Archaeological District.

Some archaeological information would undoubtedly be lost, as current archaeological techniques do not recover and analyze all data contained on a site. New techniques available in the future could not be employed at any resources committed through this program.

There may be some impact to American Indian cultural values of the area. Although native groups are often reluctant to identify sacred or significant locations, efforts will be made to identify these localities prior to construction.

It is unlikely all secondary impacts can be mitigated or avoided. Unauthorized artifact collection, although illegal on federal lands, has been and will continue to be a problem in the area. Alternative C especially will create new opportunities for access to sensitive sites. This impact can certainly be lessened; however, it can never be totally mitigated.

4.8 LAND USE

4.8.1 Introduction

The proposed action could affect land use resources, both directly (primary) and indirectly (secondary), by exerting a physical (primary) and/or visual (secondary) influence. Direct impacts would occur if construction or operation of the alternative resulted in the termination or severe modification of surrounding land use. Indirect impacts would result if construction and operation activities altered land use patterns or access to use areas adjacent to or within view of the alternative. Indirect impacts would also result if the alternative stimulated or encouraged the development of land uses not presently anticipated.

The following criteria were integrated to determine impacts to land uses: (1) potential conflicts (not considering recreation) with existing land use plans or the Forest Plan; (2) proximity to "sensitive" areas (such as a residential area); (3) termination of an existing land use or a land use incompatibility; and (4) a general characterization of impact type (including duration, quantity, and quality of the impact). Effects on recreation are described under Section 4.11, Recreation Resources.

Land uses which were identified as high sensitivity (Figure 4-10) included residences and communication facilities. Construction and operation on these uses could terminate or preclude these uses or severely alter these land uses. Rangeland/forest, oil and gas development, and agriculture were identified as moderate sensitivity.

4.8.2 Direct and Indirect Impacts

4.8.2.1 Alternative A - No Action

Construction. No significant direct impacts to land uses would occur as a result of Alternative A. Nearby residences would continue to receive adverse indirect effects primarily due to oil and gas truck traffic, dust, and noise. No direct impacts would result from construction of new flowlines on NFS Lands. Minor short-term adverse effects on certain access roads (Sauls Creek, Fosset Gulch, and Spring Creek) would occur during construction. Major long-term positive effects would occur after installation of flowlines. These positive indirect effects to nearby residences would result from reduced truck traffic (i.e., road maintenance equipment and produced water haul trucks). Further discussion of these effects is provided in Section 4.9.

Continued indirect adverse effects to nearby residences and direct effects to access roads by oil and gas truck traffic would occur if no further construction is proposed. See Transportation, Section 4.9, for further discussion.

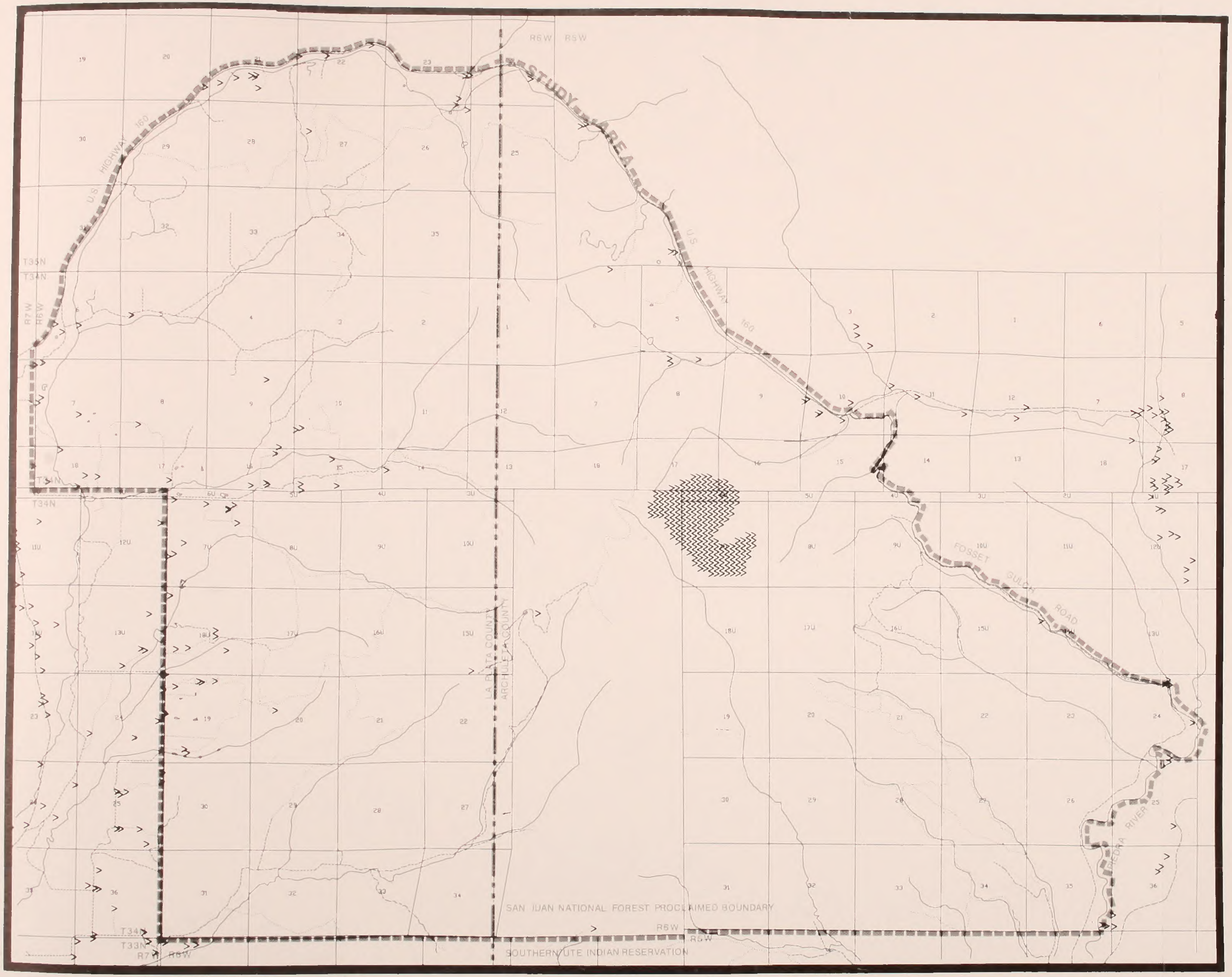
Operations. No significant impacts other than those described previously in Section 4.8.2.1 are anticipated during operations.

Abandonment. No direct impacts would occur to land uses during abandonment. Indirect adverse effects to nearby residents from oil and gas truck traffic would cease.

4.8.2.2 Alternative B - Proposed Action

Construction. No direct impacts would occur during construction of wellsites or well pads. The proximity of the nearest wellsites to residences is about 0.5 miles, with one exception where a dwelling lies adjacent to the well window (Figures 2-2 and 4-10). For these locations, short-term indirect effects would occur to approximately seven residential dwellings located near the NFS boundary. These indirect adverse effects would include construction traffic, dust, and noise. See Section 4.9.2.2 for further discussion.

No significant impacts would occur on land uses from construction of access roads and flowlines. Similar indirect effects identified above for wellsite construction would occur to nearby residences along access routes that are associated with wellsites.



LAND USE AND RECREATION SENSITIVITY

HIGH SENSITIVITY AREAS INCLUDE RESIDENTIAL AREAS, RANCHES, FARMS, COMMUNICATION FACILITIES, AND RECREATION AREA 3A

> AREA OF HIGH SENSITIVITY

NORTH

RESOLUTION: 1 HECTARE

1/4 0 1/2 1 2

MILES

HD MOUNTAINS COALBED METHANE GAS FIELD DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

PREPARED FOR SAN JUAN NATIONAL FOREST

PREPARED BY WOODWARD-CLYDE CONSULTANTS

SPRING 1990

FIGURE 4-10

No direct impacts were identified for construction of a compressor station or other facilities to land use resources.

Operations. No direct impacts were identified for the proposed action.

Abandonment. No direct impacts are anticipated during abandonment. Minor indirect effects would include reduced oil and gas traffic and noise to nearby residences.

4.8.2.3 Alternative C - Current Direction

Construction. No direct impacts would occur. However, short-term indirect adverse effects would occur to nearby residences. Approximately seven residential dwellings are located on adjacent private land or within 0.5 miles of this alternative. These indirect effects would include increases in construction noise, dust, and traffic near these residences. Potential conflicts, however, arise with the Forest Plan's 3A Management Area located along the northern slopes of Pargin Mountain. Management Area 3A consists of the Recreation Opportunity Spectrum of semi-primitive, nonmotorized recreation opportunities. Section 4.11, Recreation Resources, provides a discussion of potential effects to this management area.

No direct impacts would occur during construction of access road and flowlines. However, due to the lineal activities, short-term adverse indirect impacts would occur to nearby residences. These adverse effects are similar to indirect impacts described under Section 4.8.2.2.

Impacts to other facilities would be similar to those associated with Alternative B (see Section 4.8.2.2).

Operations. No direct impacts were identified for the operations phase by this alternative.

Abandonment. Impacts associated with Alternative C would be similar to those associated with Alternative B.

4.8.3 Impacts Summary

No direct adverse impacts would be brought about by any of the alternatives to land use resources. Table 4-13 provides a summary of indirect impacts for each alternative. The most occurrences of indirect, adverse effects would be generated during construction under Alternative C; and to a lesser extent, indirect

TABLE 4-13

ACRES OF IMPACT TO AREAS OF HIGH SENSITIVITY FOR LAND USE AND RECREATION

	Alternatives						
	A	B			C		
Ownership Land Classification		Windows	50-ft. ROW System	600-ft. Corridor System	Windows	50-ft. ROW System	600-ft. corridor System
NFS							
LU[1]	0	0	0	0	0.2	0.3	0.7
3A[2]	0	0	0	0	3.0	1.8	16.2
Total	0	0	0	0	3.2	2.1	16.9
PRIVATE							
LU	0	0.2	0	0	7.7	0	0
3A	0	0	0	0	0	0	0
Total	0	0.2	0	0	7.7	0	0
STATE							
LU	0	0	0	0	0	0	0
3A	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

[1] Land use acres of high sensitivity
[2] Recreation opportunity spectrum (ROS) Management Area 3A

adverse effects would be generated under Alternative B, to nearby residences as noise, traffic, and dust from by oil and gas truck traffic. Residences located on county roads along the western edge of the Study Area would receive short-term indirect adverse effects from traffic. New flowlines installed under Alternative A would result in a positive indirect impact by substantially reducing the nuisance to residences near access roads that is presently caused by water haul trucks.

4.8.4 Cumulative Impacts

Impacts under Alternative C would result in the most occurrences of indirect adverse effects. A total of 95 well sites would be developed, and together with the surrounding wells on private lands, could create an ongoing period of construction traffic, dust, and noise to most residences in and adjacent to the Study Area, particularly residential dwellings located along major access roads (see Transportation, Section 4.9, for further discussion).

Cumulative impacts would be substantially less from implementation of Alternative B than from Alternative C. The period of construction impacts by Alternative B would be short-term and spread over several weeks versus several months for Alternative C.

4.8.5 Mitigation Summary

The mitigation recommendations provided below, coupled with mitigation measures noted in Appendixes A-1 and A-4 and in Section 4.9, Transportation, would effectively reduce most of the indirect impacts for land use resources.

- Comply with all regulatory agency and landowner permit and lease requirements concerning general agricultural and other land use issues.

- Locate project facilities on the edges of irrigated and non-irrigated agricultural land to the maximum extent practicable to reduce direct and indirect effects on agricultural resources and operations.

- Reduce speeds of oil and gas trucks and contractor vehicles when approaching and passing residential dwellings adjacent to roads.

- Minimize crossings or other direct effects on watershed restoration facilities; agricultural irrigation facilities, including water canals, ditches, pipelines; and other water conveyance systems to the maximum extent practicable or provide for their protection to allow them to operate as designed.

- If facilities (i.e., fences, gates) are damaged, repair or replace the facility according to landowner requirements.

- Minimize project-related construction equipment and vehicle movements off specific access roads to avoid disturbance of agricultural and other land.

- Schedule concentrations of project traffic, such as truck convoys, or heavy or wide loads, to avoid periods of expected heavy traffic flows due to recreation events (e.g., hunting seasons, weekend periods).

- If well construction or drilling activities occur during deer/elk hunting season or elk migration, special signing to warn public of construction, speed limit signing, and a gated road from start of new construction should be implemented.

4.8.6 Unavoidable Adverse Impacts

Unavoidable adverse impacts would consist of short-term impacts from noise, dust, and traffic to nearby residences during construction of project facilities.

4.9 TRANSPORTATION

4.9.1 Introduction

Impact criteria for transportation would involve a change in traffic volume, change in service levels, and/or a change in road safety that would affect number of accidents and road capacity. The potential effects of construction, operations, and/or abandonment of facilities on transportation include the following:

- Increases in traffic volumes on roads located in the Study Area resulting in traffic disruption and road degradation;

- Increases in nuisances associated with project-related transportation, including generation of dust and dirt on roads;

- Increases in road traffic volume to a level that would result in a decrease in driver comfort (operating Level of Service) for more than one year;

- Increases in vehicle miles of travel causing a vehicle accident probability increase of greater than 5 percent (USDI BLM and USDA FS 1987);

- Increases in road density on the NFS lands by more than 5 percent (USDI BLM and USDA FS 1987); and

- Construction on slopes greater than 40 percent may cause slope instability, soil erosion, stream sedimentation, and difficult reclamation. Also included would be the inherent increase in worker hazards on steep slopes.

4.9.2 Direct and Indirect Impacts

4.9.2.1 Alternative A - No Action

Construction. Long-term direct impacts caused by ongoing oil and gas truck traffic would occur on major access roads further deteriorating conditions of these roads. These roads would include Sauls Creek road (FDR 608), Spring Creek road (FDR 537), and Fosset Gulch road (FDR 613). In addition, La Plata County roads 527, 526, 528, 523, 524, 522, 334, and 335 would also be further deteriorated. Indirect adverse effects (e.g. traffic, noise, and dust) caused primarily by oil and gas truck traffic would continue to occur to nearby residences.

Service levels during construction and rig-up and rig-down would be impacted by the proposed alternatives, but not during the subsequent project phases. The increase in accident probability would not be greater than 5 percent, and, therefore, would be considered a low to moderate impact.

Short-term direct and indirect adverse effects were identified during construction of new flowlines. Flowline construction could temporarily disrupt or halt traffic along existing access roads previously identified in this

section. Construction equipment may cause excessive deterioration to adjacent road segments. Construction noise and dust could be temporarily disruptive to nearby residences.

The impacts of no further development would be similar to those direct and indirect impacts for existing facilities developed on NFS lands.

Operations. Direct and indirect positive effects would primarily occur from reduced oil and gas truck traffic, noise, and dust due to flowline installation. Residual oil and gas traffic for maintenance and safety inspections would still remain; however, the need for water haul trucks would be substantially reduced. This would, in turn, reduce the rate of deterioration of major access roads previously identified in this section.

Abandonment. An incremental short-term increase in truck traffic would be generated to remove and reclaim areas of disturbance including well sites. This increase would not be significant.

4.9.2.2 Alternative B - Proposed Action

Construction. Traffic rates would increase for short-term periods during well drilling and completion, well dewatering, and construction of all facility types. Traffic rates would also increase during the installation of water pipelines. Vehicle types associated with well drilling and completion would primarily include heavy drilling and completion rigs, heavy trucks, light trucks, and automobiles. Vehicle types associated with well dewatering would primarily include heavy trucks, light-trucks, and automobiles. Vehicle types associated with construction of all types of facilities would include construction equipment (e.g., dozers, graders, backhoes), heavy trucks, light trucks, and automobiles. The movements of these types of project-related vehicles on highways and roads in the Study Area may incrementally increase traffic rates and change traffic flow patterns, resulting in some additional traffic congestion and interruption of traffic flow.

The movement of heavy drilling and completion rigs, heavy trucks, and construction equipment on highways and roads located in the project area would probably result in some physical degradation of road surfaces. More specifically, asphalt roads may undergo cracking and asphalt removal. The gravel on gravel-surfaced roads may be moved to the sides of such roads. Ruts may be caused on wet dirt roads. The magnitude and extent of these types of potential effects would vary on the basis of specific location, time, pre-project highway and road condition, past facility maintenance adequacy, and other factors.

Alternative B would create short-term direct and indirect impacts during construction of wellsites. The average volume of traffic for each wellsite would require approximately 10 vehicles per day (vpd) round trip. The duration for construction is approximately 24 days per wellsite. Table 2-2 provides a breakdown of activities, number of trips required, and duration for each wellsite.

The major access roads (Sauls Creek, Armstrong Canyon, Spring Creek, and South Fossett Gulch) would receive the bulk of construction traffic. South Fossett Gulch road would potentially receive the greatest increase, approximately 20 to 50 percent in traffic for the construction period assuming that one wellsite location was drilled at a time with the access road in place. Table 4-14 displays the potential increase on traffic of the major access roads for Alternative B during construction.

Alternative B would require approximately 23 new miles of access road and flowline ROW on NFS lands, in addition to the 19 miles of flowline ROW from Alternative A. This would not significantly increase the road density in the Study Area or on the San Juan National Forest. Impacts would occur from construction along Turkey Creek and South Fossett Gulch roads. Existing roads would be used wherever possible and upgraded as required. The traffic volume is estimated at 122 vehicle trips per quarter mile during the flowline access road construction period. The weight of trucks required in all the project alternatives would impact the existing deteriorated road system. Road capabilities would be maintained and/or upgraded to safely manage these heavy loads. For all FDRs, a road use permit would be entered into between the FS and Amoco. Further provisions are provided in Section 4.9.5, Mitigation Summary. Access roads would be used primarily during the short-term construction period, and less frequently during operations and abandonment. An incremental increase in traffic volume for State Route 151, U.S. Highway 160, and La Plata County 521 would occur during this period.

The proposed compressor station would create short-term low to moderate effects to roads FDR 613 and FDR 615. No other facilities under the proposed action would cause direct impacts to transportation.

Operations. Impacts would occur to transportation. Normal maintenance and safety inspections would create an incremental increase to the existing traffic volume of the major access roads.

Abandonment. During the abandonment phase a small short-term incremental increase in traffic would occur to the major access roads.

4.9.2.3 Alternative C - Current Direction

Construction. The combined construction of wellsites and access roads would create a major increase in traffic volume and major access road degradation. A total of 52 miles of access road and pipeline ROW is proposed on NFS lands, in addition to the 19 miles of flowline ROW from Alternative A. Impacts similar to those associated with Alternative B (Section 4.9.2.2) would occur on the Sauls Creek (LPC 527), Spring Creek (FDR 537), and South Fossett Gulch (FDR 613) access roads, except that the duration of impacts would extend for a longer period of time. In addition, other access roads, including LPC 334, 522, 524, 523, and 335, and FDR 841 and 127, would be adversely affected. Traffic volume on U.S. Highway 160, State Route 151, and La Plata County Road 521 would receive an incremental increase of impacts during the construction period. Table 4-14 provides a summary of traffic volume generated by Alternative C for construction.

Operations. Incremental impacts would occur to transportation during operation. An increase in traffic volume for the major access roads would occur for maintenance and safety inspection of wellsites; however, the increased volume over the existing condition would not be significant. Indirect impacts of traffic to nearby residences would continue.

Abandonment. No direct impacts would be incurred by Alternative C on transportation during the abandonment phase. Short-term effects of increased traffic, dust, and noise on nearby residences would occur.

4.9.3 Impacts Summary

Alternatives B and C would cause indirect long-term adverse effects to residences located along major county access roads leading into the western portion of the Study Area and along Fossett Gulch and the Piedra River. These effects would include noise, dust, and traffic safety. The cumulative effects by any of the project alternatives to U.S. 160 and State Route 151 would be incremental. Impacts, in terms of increased traffic and road deterioration, would be created on existing major access roads, including Turkey Creek and South Fossett Gulch roads by Alternative B; and Sauls Creek, Armstrong Canyon, Spring Creek, South Fossett Gulch, and Turkey Creek roads by Alternative C. Table 4-14 provides a summary of impacts by each alternative.

TABLE 4-14

AVERAGE DURATION AND TOTAL NUMBER OF VEHICLE TRIPS/ACTIVITY FOR LIFE OF PROJECT ON NFS LANDS

	Well Drilling	Completion & Testing[2]	Well Facilities Installation	Well Operations	Well Workover[3]	Compressor Site Installation	Compressor Site Operation[4]	Access Road Construction per mile	Flowline Installation per mile	Total Trips/ Alternative
Duration of Activity[1] (Days)	8	14	4	-	1	4	-	7	-	
Trips/Activity	170	46	31	-	6	176	596	486	147	
Alternative A										
0 Wells	-	-	-		-	-	-	-	-	
19 Mi. ROW	-	-	-		-	-	-	-	2,793	
Total Trips	0	0	0		0	0	0	0	2,793	2,793
Alternative B										
28 Wells	4760	1288	868		5040	-	-			
42 Mi. ROW	-	-	-		-	-	-	11,178	6,174	
1 Comp Sta	-	-	-		-	175	596	-	-	
Total Trips	4760	1288	868		5040	176	596	11,178	6,174	30,080
Alternative C										
95 Wells	16150	4370	2945		17100	-	-	-	-	
71 Mi. ROW	-	-	-		-	-	-	25,272	10,437	
1 Comp Sta	-	-	-		-	176	596	-	-	
Total Trips	16150	4370	2945		17100	176	596	25,272	10,437	77,046

[1] Average duration of days per wellsite or per mile of access road
[2] Production testing may range 7-14 days
[3] One workover/year average with well life assumed at 30 years
[4] Assumes pickup (2/day), gang truck (1/week) water truck (2/month) of 30 year life at a total of x 596 trips

Source: Table 2-2.

4.9.4 Cumulative Impacts

Impacts to major FS and La Plata County access roads would be created by project traffic. Increased traffic, road degradation, and safety problems would likely occur, adding to the existing traffic patterns. The cumulative effects for Alternative C would create the most severe direct and indirect adverse effects to the Study Area. Alternative C would increase the rate of deterioration of the road condition on La Plata County Road 521.

4.9.5 Mitigation Summary

The mitigation recommendations below, in addition to those listed in Appendix A-4, would effectively reduce or minimize direct adverse effects to transportation and indirect effects caused by transportation.

- Complete watering or other approved chemical dust-abatement procedures on heavily used dirt and gravel roads to reduce fugitive dust emissions to the maximum extent practicable.
- Provide instructions to company and contractor workers to obey speed limits and other related legal requirements.
- Provide instructions to company and contractor personnel to comply with road capacity ratings.
- For state and county roads to be used, notify the respective administration's department.
- Require company and contractor personnel to utilize adequate signing, barriers, flag-persons and other measures, including detours, to control traffic where significant project activities occur on or adjacent to roads.
- Adequately maintain project-related vehicles according to manufacturer's specifications, primarily with respect to mufflers; include company and contractor vehicles in this mitigation effort.
- Consolidate project-related vehicle trips to the maximum extent practicable to reduce traffic rates on regional access roads.
- Avoid rutting of wet dirt access roads to the maximum extent practicable by avoiding such roads, if possible, and adding gravel to roads, if needed.

- Remove all project-related deep ruts in dirt access roads at appropriate times.

- Use high capacity asphalt-surfaced roads to the maximum extent practicable for project-related traffic to reduce direct effects on gravel and dirt roads, and to reduce the generation of fugitive dust.

4.9.6 Unavoidable Adverse Impacts

Unavoidable adverse impacts would consist of increased traffic levels and rates of road surface degradation for project-affected roads.

4.10 NOISE

4.10.1 Introduction

Construction activities include noise levels associated with well drilling and completion, construction of compressor stations, and construction vehicles. Operation activities include noise levels associated with well dewatering and compressor station operations.

4.10.2 Direct and Indirect Impacts

4.10.2.1 Alternative A - No Action

Construction. These construction activities would be temporary in nature. High noise levels may be generated for very short periods of time during installation, and repairs may be necessary only infrequently. Refer to Table 4-15 for typical noise levels associated with construction activities.

Operations. No significant noise above baseline levels would result from operation activities as a result of implementing Alternative A.

TABLE 4-15

SOUND LEVELS OF VARIOUS
TYPES OF OPERATING CONSTRUCTION EQUIPMENT

Equipment Type	Sound Level at 15 Meters (50 ft) dBA
Chainsaw	90
20-250 ton Crane	88
Backhoe	85
20-30 cu. yd. Pan Loader	87
D7, D8 and D9 Bulldozers	89
Fuel and Lubrication Truck	88
Water Truck	88
Motor Grader	85
Vibrator/Roller	80
Master Mechanic Truck	88
Flat Bed Truck	88
Dump Trucks	88
Flat Bed Trailers	88
Commercial Tractors	80
Concrete Truck	74
Concrete Pumps	82
Front End Loaders	83
Road Scrapers	87
Air Compressor	82
Automobile	80

Source: Construction Engineering Research Laboratory 1978.

Abandonment. Noise levels generated by abandonment activities would be short-term and temporary. The noise levels would be similar to those associated with construction activities. Refer to Table 4-15 for typical noises associated with construction activities.

4.10.2.2 Alternative B - Proposed Action

Construction. The effects of well drilling and completion activities in the Study Area would be temporary, lasting approximately eight days for drilling and 7 to 14 days for completion at each location. Noise levels from drilling and completion operations have been monitored in support of the Environmental Planning Document Volume I for Amoco's San Juan Basin Coal Degas Project (Woodward-Clyde Consultants 1988). In this study, average day/night sound levels (L_{dn}) were approximately 69 dBA within 500 feet. Daytime sound levels associated with completion activities were approximately 50 dBA (Table 4-16). For Alternative B, all well completion activities would take place during daylight hours only.

Construction of access roads would involve the use of bulldozers, backhoes, road graders, and center-dump gravel trucks. Refer to Table 4-15 for typical noise levels associated with access road construction activity. Access road construction would be temporary, averaging 7 days per mile of road. Table 4-15 is also applicable for impacts from flowline and compressor station construction.

Operations. Noise levels associated with the operation of coalbed methane wells were monitored in support of the Environmental Planning Document Volume 21 for Amoco's San Juan Basin Coal Degas Project (Woodward-Clyde Consultants 1988). Average day/night noise levels measured within 500 feet of the wells ranged from 49 to 62 dBA, depending on the type of muffler in use (Table 4-16). By way of comparison, noise levels below an L_{dn} of 55 dBA have been identified as the maximum noise level that would not adversely affect public health and welfare by interfering with outdoor activities (EPA 1974).

Noise levels on access roads during the operational phase of Alternative B would be temporary. Typical noise levels of automobiles and pickup trucks range from 60 to 80 dBA at 50 feet.

No significant noise impacts would result from the operation of the flowlines.

Noise levels associated with the operation of compressor stations were monitored in support of the Environmental Planning Document Volume 1 for Amoco's San Juan Basin Coal Degas Project (Woodward-Clyde Consultants 1988). Average day/night noise levels measured within 500 feet of

TABLE 4-16

SOUND LEVELS OF COALBED METHANE GAS FACILITIES AND BACKGROUND SITES MEASURED UNDER VARIOUS CONDITIONS AT VARIOUS LOCATIONS PROXIMATE TO THE STUDY AREA

Facility and Location	Condition	Distance (ft)	Equivalent Sound Level (Leq in dBA)		Peak Sound Level (dBA)		Average Day/Night Sound Level[a] (Ldn in dBA)
			Daytime (Ld)	Nighttime (Ln)	Daytime (Ldp)	Nighttime (Lnp)	
County Road 311 Sec. 24, T34N, R8W	Background		39.8	44.3	48.0	48.0	50.3
County Road 324 Sec. 22, T33N, R6W	Background		41.0	32.2	45.0	38.0	41.5
County Road 308 Sec. 24, T34N, R8W	Background		43.4	38.5	61.5	40.0	44.3
Downtown Ignacio Sec. 8, T33N, R8W	Background		64.3	46.8	80.0	69.0	62.7
Lemon Compressor Sec. 24, T34N, R8W	Supercritical Muffled	100 500	63.8 53.5	79.8[b] 63.6[b]	68.5 60.0	82.0[b] 68.0[b]	85.6 69.4
Cottonwood Gulch Compressor Sec. 25, T34N, R8W	Standard Muffled	100 500	73.2 51.0	72.5 51.3	76.0 55.5	74.0 53.5	79.0 57.7
Salvadore Compressor Sec. 21, T33N, R7W	Standard Muffled	100 500	72.7 57.3	68.4 55.2	77.0 60.5	70.0 58.5	75.7 62.0
Lunt 19-1 Pumping Unit Sec. 18U, T34N, R8W	Hospital Grade Muffled	100 500	60.0 44.6	61.9 56.5	75.0 47.0	67.0 61.0	68.1 62.3
Southern Ute AB-1 Pumping Unit Sec. 16, T33N, R7W	Standard Muffled	100 500	84.5 54.2	80.3 50.1	87.0 62.5	84.5 52.5	87.6 57.4

TABLE 4-16
(Continued)

Facility and Location	Condition	Distance (ft)	Equivalent Sound Level (Leq in dBA)		Peak Sound Level (dBA)		Average Day/Night Sound Level[a] (Ldn in dBA)
			Daytime (Ld)	Nighttime (Ln)	Daytime (Ldp)	Nighttime (Lnp)	
McCaw 20-2 Pumping Unit Sec. 17U, T34N, R8W	Supercritical	100	56.0	55.9	64.5	58.0	62.3
	Muffled	500	40.9	43.2	49.0	47.0	49.3
Southern Ute 1-32 Pumping Unit/Compressor Sec. 4, T33N, R7W	Standard	100	67.7	68.8	71.0	71.5	75.4
	Muffled	500	48.8	51.3	51.5	54.0	57.4
McCaw Produced Water Disposal Station Sec. 20, T34N, R8W	Enclosed in Building	100	53.0	59.8	65.0	60.5	65.7
		500	40.2	45.3	57.0	47.0	51.3
REA 18-U-3 Completion Operation Sec. 27, T34N, R8W	Standard	100	67.3	--	84.0	--	--
	Muffled	500	50.1	--	70.5	--	--
County Road 303 Drilling Operation Sec. 22, T34N, R9W	Standard	100	69.4	70.0	72.0	72.5	76.3
	Muffled	500	57.2	63.5	62.0	65.0	69.4

[a] A night time penalty of 10 dBA is included in the calculation of the Ldn.

[b] The compressor malfunctioned during the night time measurements resulting in higher than normal sound levels.

Source: Woodward-Clyde Consultants 1988.

compressor station operations ranged from 58 to 62 dBA (Table 4-16). By way of comparison, noise levels below an L_{dn} of 55 dBA have been identified as the maximum noise level that would not adversely affect public health and welfare by interfering with outdoor activities (EPA 1974). The duration of compressor station operation would be the period of project life.

Abandonment. Noise levels associated with well abandonment activities would be similar to levels generated by drilling activities (Table 4-16).

4.10.2.3 Alternative C - Current Direction

Construction. Noise levels associated with construction of wells, access roads, flowlines, and other facilities such as compressor stations would be the same as the levels presented in Alternative B (refer to Section 4.10.2.2 and Table 4-15).

Operations. Noise levels associated with operation of wells, access roads, flowlines, and other facilities such as compressor stations would be the same as levels presented in Alternative B (refer to Section 4.10.2.2 and Table 4-15).

Abandonment. Noise levels associated with well abandonment activities would be similar to levels generated by drilling activities (Table 4-16).

4.10.3 Impacts Summary

Noise impacts from construction and operation activities depend on the distance between the noise source and the sensitive receptor. A common estimation of sound attenuation with distance is approximately a 6 dBA reduction of the sound level with each doubling of distance. For example, a sound level of 80 dBA measured at 100 feet would be approximately 74 dBA at 200 feet and 68 dBA at 400 feet. Noise levels below an L_{dn} of 55 dBA have been identified as the maximum noise level that would not adversely affect public health and welfare by interfering with outdoor activities (EPA 1974). Based on the levels measured at drilling and completion operations, wells, and compressor stations, and the estimation of noise attenuation discussed above, receptor locations greater than approximately 1000 feet from the noise source would not be adversely affected.

4.10.4 Cumulative Impacts

Because of the uncertainty of the locations of proposed facilities and their proximity to potentially noise sensitive receptors, the possibility exists that more than one facility could result in combined effects on nearby receptors. Sound levels generated by more than one source have been evaluated in the following manner.

Since decibels are logarithmic units, sound levels cannot be added by ordinary arithmetic means. For example, if the noise levels of two separate compressors were measured at 70 dBA, the combined noise, if the two were located side-by-side, would be 73 dBA, not 140 dBA. Because the sound levels are a measure of the energy contained in an acoustic signal, the addition of sound levels must be performed on an energy basis. In the example of a combined noise effect from two compressors, each with a sound level of 70 dBA, the resultant sound level is calculated using the following equation:

$$dBA\ Total = 10 \log \sum_{i=1}^{N} (dBA_i/10)$$

where $\sum_{i=1}^{N}$ *represents the summation of* N *noise levels.*

A simplified method for summing two or more noise sources is as follows:

When two noises differ by:	Add the following to the higher value:
0 - 1 dBA	3
2 - 3 dBA	2
4 - 9 dBA	1
10 or more dBA	0

When it is necessary to add more than two sound levels together, the levels are ranked in ascending order, and then added together two at a time starting with the lowest two levels.

The results of this analysis indicate that combined noise levels of more than one project facility of the types previously described would generally not be more than 3 dBA higher than the noisier of the individual facilities. Alternative B and Alternative C would each have a greater number of impacted areas due to the increased number of noise-producing facilities. However, the spacing of these facilities and their distances from a particular sensitive receptor would result in cumulative impacts at this receptor of no more than 3 dBA higher than the loudest (usually the closest) noise source.

4.10.5 Mitigation Summary

Based on the noise levels measured at drilling and completion operations, wells, and compressor stations, and the estimation of noise attenuation with distance discussed in Section 4.10.3, mitigation measures should be implemented if noise impacts at a particular receptor exceed the maximum noise level of 55 dBA. This level is identified as adversely affecting public health and welfare by interfering with outdoor activities. Generally, this level would not be exceeded if the facilities are placed more than 1,000 feet from the closest sensitive receptor.

In cases where the facilities are closer than 1,000 feet to a sensitive receptor, the following mitigation measures should be utilized separately (or in any combination) to reduce impacts to less than 55 dBa measured at the nearest receptor:

- Muffling. Several different grades of muffling systems have been developed for the types of compressors and pumping units used in the San Juan Basin area ranging from standard mufflers to hospital grade mufflers and supercritical muffling systems. These muffling systems can generally reduce sound levels by approximately 4 to 8 dBA. Maintenance of project-related construction equipment, truck, and automobile muffling systems to manufacturer's specifications should also be completed. In addition, upgraded muffling systems on drilling rigs should be utilized.

- Sound Barriers. The construction of sound barriers between the source and the receptor has been shown to reduce sound levels. The magnitude of the reduction depends on the type of material used, the distance from the source to the barrier, the height of the barrier, and the distance

between the source and the receptor. The material used for constructing the barrier must be selected so that the transmission of sound through the barrier is much less than that diffracted over the top. In general, this can be achieved by ensuring that the mass of the barrier material is at least:

- 1.3 lbs/ft^2 for an attenuation of 5 dB
- 2.3 lbs/ft^2 for an attenuation of 10dB
- 4.0 lbs/ft^2 for an attenuation of 15dB

Specific types of sound barriers which could be used include the following:

- Sound barriers with or without insulation surrounding compressors and pumping units;

- Planted tree barriers, specifically using fast-growing species such as the Lombardi poplar around compressors and pumping units; and

- For short-term use, strategic placement of solid obstacles at appropriate locations in the areas of compressor stations and pumping units.

In addition to these types of barriers, it may be possible to enclose compressors and disposal well facilities inside buildings similar to the building currently housing the Amoco San Juan Basin McCaw disposal well facilities. Use of this building is currently resulting in substantial noise reductions.

- Existing Topography. The existing topography and vegetation of the Study Area can also be used to reduce noise generated by proposed project facilities. Hills, trees, and other vegetation have been shown to be effective in reducing noise levels at sensitive noise receptors. Reductions on the order of 10 dBA, depending on the frequency of the noise source, the geometry of the proposed location, and the type and thickness of the vegetation barrier (Edison Electric Institute 1978) can be achieved.

4.10.6 Unavoidable Adverse Impacts

With proper use of the mitigation measures discussed in Section 4.10.5, no adverse noise impacts are expected to result from project construction and operation in either short-term or long-term time frames.

4.11 RECREATION RESOURCES

4.11.1 Introduction

The purpose of this section is to identify and characterize recreational resources in the vicinity of the proposed project in order to assess what effects the construction and operation of each alternative may have on existing and planned recreational opportunities. The implications of higher use levels that could be caused by increases in population during the life of the project are described for the alternatives. The effects to be considered include temporary disruption of use, elimination of use, and increased use. This section focuses on the various forms of recreation which occur in the regional area, but it also addresses potential project-related problems (e.g., poaching, unauthorized off-road vehicle use, littering, vandalism, "pot-hunting"). Potential sensitivity about the quality of recreation experiences resulting from the presence of project-related facilities are described.

Recreational resources could be affected both directly (primary impacts) by physical changes to resources, and indirectly (secondary impacts) by visual or use (secondary) influence. Primary impacts would occur if construction or operation of the project resulted in the termination of use or substantial modification to recreational resources within and adjacent to the Study Area. Secondary impacts would result if construction and operation activities altered recreation use patterns or recreation demand and access to use areas near the proposed project.

Below are impact criteria identified for recreational resources. These include project-related changes that would:

- Alter or otherwise physically affect established, designated, or planned recreational use area or activities;
- Affect officially adopted policies or goals for recreational land management of recognized organizations, or agencies;
- Increase or decrease accessibility to areas established, designated, or planned for recreational use;
- Affect the duration, quantity, and quality of impact to recreational resources; and/or

- Change recreation opportunity that would violate the objectives of existing recreation opportunity spectrum (ROS) classifications.

Impacts identified for recreational attractions, developed recreation sites, and dispersed recreational activities are described below.

4.11.2 Direct and Indirect Impacts

4.11.2.1 Alternative A - No Action

Construction. Existing oil and gas traffic would continue to affect hunting patterns, quality of hunting, and other dispersed recreation experiences.

Short-term adverse effects would occur if new flowline construction activities took place during the big game hunting seasons. Effects in terms of animal displacement and possibly hunter displacement would occur. Short-term adverse effects of dust, noise, and traffic could affect the quality of recreation opportunity for dispersed activities including camping, hiking, and horseback riding. Dispersed activities, including firewood gathering and sightseeing, could be adversely affected if flowline construction activities created temporary road closures. There would be no change to the existing unroaded area of 17,894 acres.

The potential for project related problems such poaching, unauthorized off-road vehicle (ORV) use, littering, vandalism, and "pot hunting" is substantially increased by this alternative. A total of 52 miles of new access roads would be constructed by this alternative, potentially increasing the vulnerability for illegal activity.

Operations. No impacts were identified.

Abandonment. No impacts were identified.

4.11.2.2 Alternative B - Proposed Action

Construction. No direct adverse impacts were identified. Short-term indirect impacts of noise generated by site preparation equipment and drilling activity would carry for some undetermined distance and could potentially affect big game hunting seasons and dispersed activities of camping, horseback riding, and hiking. Hunters could potentially be displaced for a short period of time.

No direct impacts were identified for access road/flowline ROW. Impacts associated with Alternative B are similar to flowline construction for Alternative A (see Section 4.11.2.1.). The unroaded area would be reduced to 15,590 acres.

No direct impacts were identified for recreation resources. Indirect effects may occur from noise and construction traffic if the proposed compressor station located on the existing Bull Creek well pad is constructed during the big game hunting seasons.

The potential for project related problems such poaching, unauthorized off-road vehicle (ORV) use, littering, vandalism, and "pot hunting" is substantially increased by this alternative. A total of 52 miles of new access roads would be constructed by this alternative, potentially increasing the vulnerability for illegal activity.

Operations. No direct impacts were identified. Noise generated from well pad machinery would likely adversely affect the quality of dispersed recreation activities (e.g., hunting, horseback riding, camping, and hiking). Hunters could potentially be displaced from hunting near locations around wellsites. New access roads could create additional recreation opportunity for sightseeing and firewood gathering.

Abandonment. No impacts would occur. The quality of dispersed recreation activity would be restored because the oil and gas land use conflicts of traffic, dust, and noise would be eliminated.

4.11.2.3 Alternative C - Current Direction

Construction. Adverse impacts were identified for the quality of recreation opportunities for dispersed recreation activities. Noise, dust, and traffic volume generated by this alternative would impact recreation qualities for hunting, camping, horseback riding, and hiking. Temporary road closure could disrupt traffic patterns for hunters, recreation sightseers, and firewood gatherers.

Adverse effects were identified with regard to potential conflicts of the Recreation Opportunity Spectrum (ROS) Management Prescription Area 3A located north of Pargin Mountain. The ROS management classification is managed for semi-primitive, nonmotorized (SPNM) recreation opportunity. Wellsite and road access development would create short-term adverse direct and indirect impacts. The physical and social setting components would be adversely affected. For the physical setting, impacts could potentially be visually evident or not remain visually subordinate. Also, ground disturbance would occur. Noise generated by the wellsite

could be potentially degrading to the social setting component. Approximately 21.0 acres of SPNM ROS are within the well window and ROW corridors which could potentially be affected by this alternative.

The potential for project related problems such as poaching, unauthorized off-road vehicle (ORV) use, littering, vandalism, and "pot hunting" is substantially increased by this alternative. A total of 52 miles of new access roads would be constructed by this alternative, potentially increasing the vulnerability for illegal activity.

Operations. No direct impacts were identified for recreation. During the operational phase, Alternative C would create a substantial number of new access roads for sightseeing, firewood gathering, and other dispersed recreation activities. The quality of recreation experience would remain affected by intermittent well site activity, oil and gas traffic, dust, and overall noise. This alternative would remain vulnerable to unauthorized or illegal activities previously described in Section 4.11.2.3.

Abandonment. No significant impacts were identified. The effects associated with Alternative C would be similar to those associated with Alternative B (see Section 4.11.2.2).

4.11.3 Impacts Summary

Long-and short-term impacts on recreation opportunities and activities would result. For the proposed alternatives, Alternative C would create the most occurrences of impact to recreation resources. Major recreation opportunities would also be generated by this alternative in terms of recreation access roads. For the ROS SPNM area, the classification could potentially pose additional constraints for oil and gas operations in this area for Alternative C. Alternative C would create a disturbance to recreation opportunities and activities over a wider area than Alternative B. Temporary noise, dust, and oil and gas traffic during construction would create short-term indirect impacts for all the project alternatives. Although Alternative C provides a greater amount of available road access which would enhance certain dispersed activities, this alternative is most vulnerable to potential project related problems such as reduced wildlife habitat and populations, poaching, unauthorized ORV use, littering, vandalism, and "pot hunting."

4.11.4 Cumulative Impacts

The cumulative effects brought about by the project alternatives and other ongoing and planned projects suggest recreation effects would be primarily contained in the Study Area. However, hunting displacement may occasionally occur outside the Study Area. A minor incremental increase in use by the project related

population of regional recreation attractions such as Navajo Reservoir State Recreation Area, Chimney Rock Archaeological Area, Vallecito Reservoir, and Weminuche Wilderness is likely to occur.

In addition, the development of new and improved roads into the area may stimulate logging activity in areas not presently accessible or which have not been approved for timber sales. The non-roaded area would be reduced from 17,894 acres for Alternative A, to 15,590 acres for Alternative B, and 7,962 acres for Alternative C.

4.11.5 Mitigation Summary

Recreation impacts that would occur as a result of construction and operation of the proposed project or alternatives could be reduced through the application of a variety of mitigation procedures including:

- Moratorium periods that would temporarily restrict construction activities and well operation activities during big game hunting seasons.

- If well construction or drilling activities occur during deer/elk hunting season or elk migration, special signing to warn the public of construction, speed limit signing, and gated roads from start of new construction should be implemented.

- Some year-round road closures to public use may be implemented.

- Enforcement of road closure requirements to prevent unauthorized motorized use of the access roads.

4.11.6 Unavoidable Adverse Impacts

Unavoidable adverse impacts would include short-term indirect impacts from project construction-related noise, dust, and traffic. Long-term impacts could include reduced hunting opportunities, and increased poaching, unauthorized ORV use, littering, vandalism, and "pot hunting." The non-roaded area would be reduced from 17,894 acres for Alternative A, to 15,590 acres for Alternative B, and 7,962 acres for Alternative C.

4.12 SOCIOECONOMICS

4.12.1 Introduction

Socioeconomic effects of the alternatives would be similar in nature but would vary in magnitude. Each would involve field development activities which would generate employment. The activities associated with the development would likely be performed by oil and gas service companies located in Farmington, New Mexico and La Plata County. Employees of these companies are likely to be existing residents of these areas. Therefore, little, if any, population growth would occur as a result of any of the alternatives.

Because little population growth is anticipated from any alternative, the demand for local government and school district facilities and services from each alternative would also be minimal, with the following exceptions:

- Increased heavy vehicle traffic would result in deterioration of county roads that provide access to the specific components associated with each alternative. This deterioration would generate an incremental demand on the county road department for road maintenance services. These impacts are discussed in Section 4.9.

- The La Plata County Sheriff's Department may experience an increased demand for traffic-enforcement activities on access roads associated with each alternative.

The direct local economic effects of all alternatives would include project-related material, supplies and equipment purchases, fees paid to contractors, and wages and salaries paid to employees. Royalty fees would accrue to owners of private mineral rights. Indirect economic effects would include local purchases made by employees of Amoco and its contractors.

Each alternative would generate certain public sector tax revenues: These include the following:

- Federal mineral royalties, of which 25 percent of the collections are returned to the counties for schools and roads (present in each respective county);

- Colorado sales and use taxes;

- La Plata and Archuleta County sales taxes on purchases in those counties;

- Bayfield, Ignacio, and Durango sales taxes on purchases in those municipalities;
- La Plata and Archuleta County and appropriate school district ad valorem property taxes on facilities and production in each of those jurisdictions;
- Colorado severance taxes (a portion of which are returned to the counties and municipalities based on the residence of project-related employees);
- Gross ton-mile and motor fuel taxes paid by Amoco and project-related contractors and vendors; and
- Colorado corporate and personal income taxes.

Some of the tax revenues listed above, primarily sales and use taxes, would flow primarily during the construction phase of each alternative; others, notably ad valorem property and severance taxes, would flow throughout the production phase of each alternative (assuming producing wells).

Each of the alternatives will also have certain effects on area social conditions, including attitudes, opinions, and lifestyles. Since each of the three alternatives involve some surface disturbances and would eventually generate produced water which would require disposal, individuals and groups who have concerns about the environmental and aesthetic effects of coalbed methane development activities in the county are likely to be dissatisfied as a result of the development activities associated with all alternatives. Clearly, the intensity of dissatisfaction would increase relative to the level of development associated with the alternative.

Individuals and groups who use NFS lands within the Study Area for recreation purposes are likely to experience dissatisfaction as a result of increased industrial activities. Certain residents of areas located along the access routes to wellsites and near drilling and construction areas are particularly likely to experience dissatisfaction and conflicts with existing lifestyles under each alternative. Dissatisfaction and conflicts will stem from the noise, dust, and safety effects of drilling and construction traffic; and the noise, visual, and aesthetic effects of drilling and infrastructure construction activities. Again, the intensity of dissatisfaction and conflict is likely to vary in proportion to the intensity and duration of development activities associated with each alternative.

As discussed in Section 3.12, many of the residents who live adjacent and along access roads to the Study Area choose to live there because of the rural, agricultural, and open space nature of the area. Consequently, dissatisfaction and conflict would stem not only from impacts such as those discussed above, but also from the change from a rural residential, agricultural, and open space land use to one of widely spaced light industry.

These activities and changes would affect people differently. Some people are not concerned by it; others, particularly those with an economic interest, welcome it. Still other residents are distressed as evidenced by their individual and organizational responses to the scoping process. Whether any of the alternatives would lead to additional individual, organizational and/or institutional responses depends, in part, on the intensity and duration of development-related activities associated with the particular alternative, and the success of visual, traffic, land use, noise, recreation, and socioeconomic mitigation measures.

Each alternative has some potential to affect the value of nearby property values. Residential property values reflect supply and demand conditions and the amenities and disamenities associated with a particular piece of property. While general housing demand in La Plata County is increasing, neither the proposed action nor either of the alternatives would generate substantial additional population or housing demand.

Amenities and disamenities are often subjective. Proximity to work and shopping opportunities may be amenities for some; rural settings and scenic vistas may be amenities for others. Clearly, many of the residents of areas adjacent and along access roads to the Study Area consider rural settings and scenic vistas to be amenities. Presumably, some portion of the real estate market for these properties would also value these amenities. To the extent that the proposed action or alternatives would negatively impact these amenities for a particular residential property, then the values of that property could be negatively affected.

There are several circumstances in which property values could be affected by each of the alternatives under consideration. These circumstances include the following:

- Disamenities such as dust, noise, traffic and safety hazards would accrue to residents along access roads to the Study Area during the field development phase of each alternative. For Alternatives A and B, the duration of these impacts would be one year and one to three years, respectively. The successful implementation of transportation mitigation measures discussed in Section 4.9.5 would reduce the negative effects of these disamenities.

- Disamenities such as noise and visual effects would accrue to residents near development activities within the Study Area, especially for Alternatives B and C. The duration of noise disamenities would be short-term and subside during project operations. Visual disamenities could be longer term, but some would be expected to diminish as revegetation occurs. The successful implementation of visual and noise mitigation measures discussed in Sections 4.6.5 and 4.10.5 would reduce the negative effects of these disamenities.

- In the event that any property were to receive environmental damage (such as contamination of water wells) from activities associated with any alternative, disamenities would accrue to any property so damaged. According to the environmental studies conducted for this document, the potential for environmental damage to private or public land is extremely low.

- Potential disamenities could accrue to residents of the area adjacent to the Study Area as the land use changes from rural, agriculture, and open space to widely spaced light industrial uses. It is generally accepted that a change to a more intensive land use, such as industrial, can create negative effects on the value of properties within communities (Muller 1976; Stull 1971). While there has been little research on the effects of industrial activities on the value of rural properties [except in the case where such properties have sustained environmental damage (Rowe and Shulze 1987)], it is reasonable to assume that there is a potential for such effects to occur. The factors that could generate such effects include the noise, visual, and traffic effects discussed above.

Factors that would mitigate such effects would include the following:

  - The 320-acre spacing requirement for coal-bed methane wells;

  - Activity associated with each alternative would occur primarily on federal land and at some distance from most existing residences; and

  - Traffic and development activities, while fairly intensive, are short in duration except for Alternative C. The level of activity associated with a producing wellfield is fairly minimal.

4.12.2 Direct and Indirect Impacts

4.12.2.1 Alternative A - No Action

Construction. Alternative A involves the development of flowlines to serve the currently drilled wells within the Study Area. Employment associated with these activities would be provided by contractors currently operating in the area and involve an estimated ten workers. There would be no population growth associated with Alternative A. Local government facility and service impacts would be limited to minimal demands on county road departments and law enforcement agencies.

Economic effects of Alternative A would include project-related material, supplies, and equipment purchases; fees paid to contractors; wages and salary paid to employees; and royalties for those wells where the mineral rights are not owned by the federal government. No estimates of the amounts associated with these economic effects are available for Alternative A, nor are estimates available concerning the amounts that would accrue to the local economies. Local government tax revenues accruing from construction of the collection and gathering systems would stem primarily from sales tax on purchases in La Plata County. In the absence of expenditure data, these amounts cannot be estimated.

The traffic-related noise, dust, and safety effects associated with Alternative A construction activities would promote dissatisfaction among residents of areas adjacent to the access roads to the construction sites. Given the relatively limited nature of development, the activities that promote this dissatisfaction would be fairly short lived.

Operations. Employment associated with the operations phase of Alternative A would include one employee who would visit each well daily. This is likely to be an existing Amoco employee. Workover crews would visit each well annually. These are likely to be existing crews coming from Farmington. No population growth from the operation phase is anticipated. Demand for local government road maintenance and law enforcement services is anticipated to be minimal.

Local government tax revenues associated with this alternative would flow from the ad valorem tax on production and equipment. In addition, counties would receive 25 percent of income received by the Federal government from these wells to be used for schools and roads. These revenues would accrue to La Plata and Archuleta Counties and certain school districts. Table 4-17 presents projections of the production-related ad valorem tax revenues that would flow from Alternative A for the 1991 through 2000 period.

TABLE 4-17

ALTERNATIVE A—NO ACTION
PROJECTION OF PRODUCTION-RELATED AD VALOREM TAX REVENUES
FOR ALL JURISDICTIONS

Year Payable	LaPlata County	Bayfield School District	Ignacio School District	Archuleta County	Archuleta School District 10	Archuleta School District 50	All Jurisdictions
1991	$0	$0	$0	$0	$0	$0	$0
1992	34,892	131,583	41,626	4,933	2,941	11,286	227,261
1993	73,273	276,325	87,415	10,359	6,177	23,700	477,248
1994	76,936	290,141	91,786	10,877	6,486	24,885	501,111
1995	80,783	304,648	96,375	11,421	6,810	26,130	526,166
1996	84,822	319,880	101,194	11,992	7,150	27,436	552,475
1997	89,063	335,874	106,254	12,591	7,508	28,808	580,098
1998	93,517	352,668	111,567	13,221	7,883	30,248	609,103
1999	98,192	370,301	117,145	13,882	8,277	31,761	639,558
2000	103,102	388,817	123,002	14,576	8,691	33,349	671,536
Cumulative	$734,581	$2,770,237	$876,364	$103,850	$61,923	$237,603	$4,784,558

Source: Amoco Production Company 1990
Planning Information Corporation 1990

Projected ad valorem tax revenues for all jurisdictions total $4,785,000. Figure 4-11 displays annual ad valorem tax revenues related to production that would accrue to all jurisdictions under each alternative. These projections and projections for Alternative B were prepared using confidential Amoco production and gas sales price forecasts. Property tax revenues are based on 1990 mill levies for each jurisdiction.

Abandonment. Socioeconomic effects of abandonment are anticipated to be minimal for Alternative A. As industrial activities cease and disturbed areas are reclaimed, levels of dissatisfaction among area residents and certain other users of NFS lands can be anticipated to subside.

4.12.2.2 Alternative B - Proposed Action

Construction. Employment associated with Alternative B would be induced by well drilling and completion, and well site, road construction, and flowline construction activities. Each of these activities would be performed by contractors. Well drilling activities would be performed by drilling contractors from the Farmington area. Amoco anticipates that four drilling crews would be operating continuously (two in the Pargin Mountain area and two in the western portion of the Study Area). The number of workers per crew ranges from 6 to 19, depending on the activities the crew is performing; therefore, 24 to 76 workers would be employed in the Study Area on drilling activities at any one time. Amoco anticipates using drilling contractors from Farmington. Drilling crews would commute daily from Farmington to the Study Area.

Well completion crews would also be provided by Farmington area contractors. The number of workers on a completion crew varies from 5 to 20, depending on the completion activity. The larger crew typically occurs for only two days during well fracturing operations. The completion phase typically lasts from 8 to 12 days. Two to three completion crews would be operating in the Study Area at any one time; one or two in the Pargin Mountain area and one in the western portion. Therefore, the total number of completion crew workers associated with Alternative B would range from 15 to 60. One three-person crew would install production-related equipment at the wellhead following well completion activities. Road construction activities would likely be performed by contractors from La Plata County. There would be one or two crews performing road construction activities, with five to ten workers per crew. Therefore, the total number of road construction workers associated with the project would range from 10 to 20 workers.

Wellsite construction activities are likely to be performed by La Plata County contractors. Two five-person crews would be required. Therefore, a maximum of ten persons associated with wellsite construction activities would be located within the Study Area at any one time.

Projected ad valorem tax revenues for all jurisdictions total [illegible]. Figure 4-11 displays the ad valorem tax revenues related to production that would accrue to all jurisdictions under each alternative. These projections and projections for Alternative B were prepared using estimated annual production and gas sales price forecasts. Property tax revenues are based on 1990 mill levels for each jurisdiction.

Abandonment. Socioeconomic effects of abandonment are anticipated to be minimal for Alternative A. As individual wells are plugged and disturbed areas are reclaimed, levels of dissatisfaction among area residents and outside visitors [illegible] would be anticipated to subside.

4.10.2.2 Alternative B - Proposed Action

Construction. Employment associated with Alternative B would be induced by well drilling and completions, and well site, road construction, and facilities construction activities. Each of these activities would be performed by contractors. Well drilling activities would be performed by drilling contractors from the Farmington area. Amoco anticipates that three drilling crews would be operating concurrently (two in the Pargin Mountain area and one in the western portion of the Study Area). The number of workers per crew ranges from 8 to 16, depending on the activities the crew is performing; therefore, 24 to 75 workers would be employed in the Study Area on drilling activities at any one time. [illegible] from Farmington. Drilling crews would commute daily from Farmington to the Study Area.

Well completion crews would also be provided by Farmington area contractors. The number of workers on a completion crew varies from 5 to 20, depending on the completion activity. The larger crew typically exists for only two days during well fracturing operations. The completion phase typically lasts from 8 to 12 days. Two to three completion crews would be operating in the Study Area at any one time; one or two in the Pargin Mountain area and one in the western portion. Therefore, the total number of completion crew workers associated with Alternative B would range from 15 to 60. One three-person crew would install production-related equipment at the wellhead following well completion activities. Road construction activities would likely be performed by contractors from La Plata County. There would be one or two crews performing road construction activities, with five to ten workers per crew. Therefore, the total number of road construction workers associated with the project would range from 10 to 20 workers.

Wellsite construction activities are likely to be performed by La Plata County contractors. Two five-person crews would be required. Therefore, a maximum of ten persons associated with wellsite construction activities would be located within the Study Area at any one time.

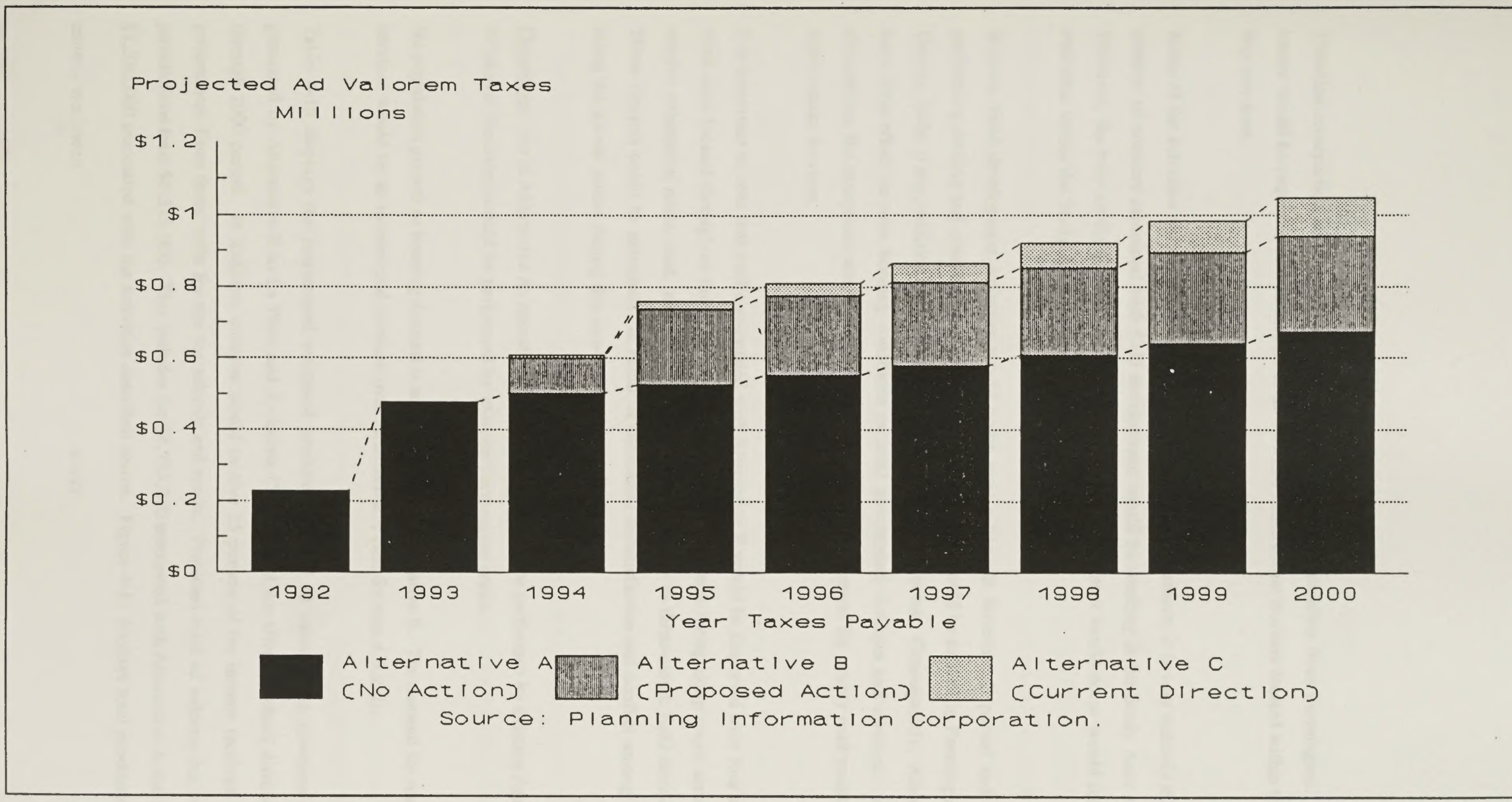


FIGURE 4-11
PROJECTED PRODUCTION-RELATED AD VALOREM TAXES
ALTERNATIVES A, B & C
ALL JURISDICTIONS

Flowline construction activities are likely to be performed by contractors from Farmington. Two 10-person crews would be required, or a maximum of 20 flowline construction workers located within the Study Area at any one time.

Some of the activities described above are sequential in nature; therefore, it is very unlikely that the maximum number of workers associated with field development would be working in the Study Area at any one time. However, the two- or three-month period in which field development would occur would result in intensive activities within the Study Area.

Because field development activities would occur over a two- to three-month period and the contractors performing drilling and construction activities for Alternative B would be located in Farmington and La Plata County, little, if any, additional population growth is anticipated to occur. Consequently, Alternative B would have little effect on area housing conditions or local government facilities and services. As in the other alternatives, the exceptions would include an intensive period of demand for county road maintenance and law enforcement services.

It is important to note that traffic associated with Alternative B would be dispersed over four access routes to work sites located throughout the Study Area. Nevertheless, residents living along major access routes could receive substantial noise, dust, and safety impacts during the two- to three-month field development period. These impacts could be anticipated to result in substantial dissatisfaction and conflict among some residents along the access routes during this two- to three-month period.

Operations. As in Alternative A, operations functions are likely to be performed by existing Amoco personnel. Workover functions would be performed by existing Farmington crews.

No population growth or housing demand is anticipated from Alternative B. The demand for road maintenance services would be an incremental increase over Alternative A (see Section 4.9.2.2).

Table 4-18 displays the incremental estimated production-related ad valorem tax revenues that would be generated by Alternative B to La Plata and Archuleta Counties and the affected school districts for the 1990 through 2000 period. In addition, counties would receive 25 percent of the income received by the Federal government from these wells for use for schools and roads. Projected total ad valorem tax revenues for all jurisdictions total \$6,315,000. This includes the \$4,785,000 associated with Alternative A and an incremental \$1,530,000 associated with the activities described above. Figure 4-11 displays total production-related ad

TABLE 4-18

ALTERNATIVE B—PROPOSED ACTION
PROJECTION OF PRODUCTION-RELATED AD VALOREM TAX REVENUES
FOR ALL JURISDICTIONS

Year Payable	LaPlata County	Bayfield School District	Ignacio School District	Archuleta County	Archuleta School District 10	Archuleta School District 50	All Jurisdictions
1991	$0	$0	$0	$0	$0	$0	$0
1992	34,892	131,583	41,626	4,933	2,941	11,286	227,261
1993	73,273	276,325	87,415	10,359	6,177	23,700	477,248
1994	88,901	311,233	124,952	19,662	6,486	50,011	601,244
1995	105,909	348,940	166,023	29,870	6,810	78,894	736,446
1996	111,204	366,387	174,324	31,364	7,150	82,839	773,268
1997	116,764	384,707	183,040	32,932	7,508	86,981	811,932
1998	122,602	403,942	192,192	34,578	7,883	91,330	852,528
1999	128,732	424,139	201,802	36,307	8,277	95,896	895,155
2000	135,169	445,346	211,892	38,123	8,691	100,691	939,912
Cumulative	$917,446	$3,092,603	$1,383,266	$238,128	$61,923	$621,629	$6,314,995

Source: Amoco Production Company 1990
Planning Information Corporation 1990

valorem tax revenues that would accrue to all jurisdictions under each alternative. An estimated $335,000 sales tax revenues would accrue to the state of Colorado. Sales tax revenues would also accrue to La Plata County on purchases made within the county.

Dissatisfaction and conflicts stemming from the traffic-related impacts can be expected to subside during the operations phase. Similarly, dissatisfaction experienced by forest users and residents of areas adjacent to the Forest can be anticipated to subside as activities are reduced to operation levels and areas of disturbance are revegetated. While certain users of NFS lands may enjoy the added access to Study Area land resulting from wellfield access roads, others would experience dissatisfaction in the change from relatively primitive open space to widely scattered industrial activities.

Abandonment. The socioeconomic effects of abandonment are anticipated to be minimal for Alternative B. As industrial activities cease and disturbed areas are reclaimed, levels of dissatisfaction among area residents and certain other users of NFS lands can be anticipated to subside.

4.12.2.3 Alternative C - Current Direction

Construction. Alternative C would include those construction activities described under Alternative B (28 wells in the first year or two) plus an average of about 12 wells per year for the next seven years. The result would be one year of intensive activity within the Study Area followed by six years of moderate activity.

During the first year of development, employment effects and impacts would be similar to those described under Alternative B. During subsequent years, assuming only one crew per each of the wellfield development activities, a reduced level of development activities would occur in the Study Area during the field development phase.

Based on those assumptions, Alternative C would generate no additional population or housing demand. The La Plata County Road Department would have one year of intensive road maintenance demands and six years of moderate road maintenance demands. Similarly, the La Plata County Sheriff's Department would experience one season of more-intensive demand for traffic-enforcement services and six seasons of moderate demands.

Field development traffic-related impacts to residents living along access roads (similar to those associated with Alternative B) would occur in the first year, with less intensive traffic impacts occurring over the next six

years. The resulting dissatisfaction and conflict would therefore be sustained throughout the field development period, although perhaps at somewhat diminished levels after the first year.

Dissatisfaction experienced by recreational and hunting users of NFS lands within the Study Area resulting from construction activities and disturbance would be sustained throughout the field development period. Given that wellfield development activities would occur at different locations within the Study Area at different times, the potential for dissatisfaction and conflict from residents living adjacent to the Study Area would exist throughout the wellfield development period.

Operations. Operation activities associated with Alternative C would very likely require the hiring of an additional well maintenance person. The economic effects for this alternative would include those described under Alternative B. Production assumptions for the incremental wells not associated with Alternative A were developed from confidential Amoco estimates. These assumptions reflect substantially lower production than either Alternatives A or B. Colorado sales tax revenues would total an estimated $950,000. Sales tax revenues would accrue to La Plata County from purchases made within the county. Projected ad valorem property tax revenues associated with Alternative C are presented in Table 4-19. Projected ad valorem tax revenues for all jurisdictions total $6,696,000. This includes the $4,785,000 associated with Alternative A, an incremental $1,530,000 associated with Alternative B, and an incremental $38,000 associated with the activities described above. Figure 4-11 displays total production-related ad valorem tax revenues that would accrue to all jurisdictions under each alternative. In addition, counties would receive 25 percent of the income received by the Federal government from these wells for use for schools and roads.

Abandonment. The site-specific socioeconomic effects of abandonment are anticipated to be minimal for Alternative C. As industrial activities cease and disturbed areas are reclaimed, levels of dissatisfaction among area residents and certain other users of NFS lands can be anticipated to subside.

4.12.3 Impacts Summary

As noted in the introduction to this section, potential positive and adverse impacts associated with all three alternatives are similar in nature but vary substantially in intensity and duration. Employment, economic, and tax revenue effects vary according to the level of development associated with the specific alternative.

TABLE 4-19

ALTERNATIVE C—CURRENT DIRECTION
PROJECTION OF PRODUCTION-RELATED AD VALOREM TAX REVENUES
FOR ALL JURISDICTIONS

Year Payable	LaPlata County	Bayfield School District	Ignacio School District	Archuleta County	Archuleta School District 10	Archuleta School District 50	All Jurisdictions
1991	$0	$0	$0	$0	$0	$0	$0
1992	34,892	131,583	41,626	4,933	2,941	11,286	227,261
1993	73,273	276,325	87,415	10,359	6,177	23,700	477,248
1994	89,390	312,530	125,964	20,679	6,916	52,507	607,986
1995	107,449	353,027	169,213	33,073	8,166	86,755	757,683
1996	113,809	373,539	179,534	36,969	9,523	96,595	809,971
1997	120,349	394,719	190,074	41,172	10,996	107,203	864,513
1998	127,159	416,558	201,219	45,703	12,592	118,630	921,861
1999	134,349	439,594	213,004	50,584	14,320	130,931	982,781
2000	141,940	463,891	225,463	55,644	16,190	143,609	1,046,737
Cumulative	$942,608	$3,161,766	$1,433,513	$299,117	$87,821	$771,216	$6,696,041

Source: Amoco Production Company 1990
Planning Information Corporation 1990

For Alternative A, the disturbance and construction activities associated with wellfield development have mostly already occurred. The construction of flowlines associated with Alternative A would have the effect of reducing traffic in the area from water haul trucks. Therefore, the relatively short duration of construction traffic might be more easily accepted by residents living on Study Area access roads. This would be particularly true if these residents were aware of the purpose and short duration of the construction activities.

Similarly, the construction activities associated with Alternative B might be more easily tolerated by residents living adjacent to the Study Area and along access roads if they were aware that, although the field development phase of the alternative would generate intensive levels of activities and traffic, the duration of the activities would be relatively short-term, and then would subside to the minimal level of activity associated with field operations.

However, Alternative C, with one season of intensive development and six seasons of moderate development activity, is likely to generate a sustained level of dissatisfaction and conflict among certain residents living adjacent to the Study Area and along access roads.

4.12.4 Cumulative Impacts

The socioeconomic impacts of Alternative B (which would include those of Alternative A) and Alternative C (which would include those of Alternatives A and B) would be cumulative. In addition, because coalbed methane activities have been occurring in the geographic area near the Study Area, and such activities would likely be occurring in the future, cumulative socioeconomic impacts resulting from the activities also occur. These include positive impacts (economic, employment, 25 percent fund, and tax revenue) and negative impacts (traffic, noise, dust, visual, and concerns about health and safety and property values). Companies contemplating such activities are not required to provide detailed information in advance (except in the case of major facilities) because the timing, schedule, and location of future activities near the Study Area is not known at the time of this analysis.

4.12.5 Mitigation Summary

Mitigation measures identified under the sections on Visual Resources (4.6.5), Land Use (4.8.5), Transportation (4.9.5), Noise (4.10.5), and Recreation (4.11.5), if successfully implemented, would reduce the socioeconomic impacts associated with each alternative. In addition, for Alternatives A and B, a public information program which would inform residents of areas adjacent to NFS lands and along access roads and users of NFS lands

within the Study Area about the nature and duration of activities could reduce dissatisfaction and conflict during the field development phases of these alternatives.

4.13 HEALTH AND SAFETY

4.13.1 Impacts Summary

Potential risks to people associated with implementation of the alternatives would include the following:

- Human-caused wildfire ignitions
- Natural gas flowline leakage or rupture
- Risks associated with well field development and traffic

The Forest Plan Final EIS (FS 1982) provides the following summary of potential effects of wildfires to public safety:

"Over the 20 year period from 1961 to 1980, approximately 22 percent of the wildfires on the San Juan National Forest were human-caused. The risk of human-caused wildfire ignitions will increase significantly under all alternatives [of the Forest Plan] because of the projected increased use of the Forest during the fire season. However, this increase in risk can be mitigated to tolerable levels through an intensified wildfire prevention program. Increased risk does not necessarily lead to wildfire; the Forest has experienced a significant increase in human use during the past 20 years without an increase in the incidence of human-caused wildfire ignitions." (Final Environmental Impact Statement, IV-149).

The FEIS recognizes that increased human use of the Forest can lead to increased risk of wildfire. Use of the area by construction crews and the general public are both of concern; however, construction and operating personnel would be required to adhere to fire prevention measures in all authorized activities (Appendixes A-1 and A-4). In addition, use of the area by the general public should not lead to an increased risk of fire. No wildfires have been caused by oil and gas activities on the Forest since their inception in 1980 (Bell, personal communication,1989).

Natural gas flowline/pipeline leaks are also of concern. The Forest Plan FEIS also addresses this aspect of public safety:

> "Pipeline leaks, which occur routinely in developed fields, are of particular concern during production. Pipelines can be subjected to a variety of destructive forces such as rapid downslope movement of snow and rock, floods, erosion, and the slow but relentless forces of solifluction and frost heaving on steep slopes. These forces insert a degree of unpredictability and a potential for massive spills due to pipeline breakage" (FEIS, IV-118).

Under Alternatives A, B, and C, all permits for gas pipelines shall meet the following requirements: All designs, materials, and construction, operation, maintenance, and termination practices employed with this use shall be in accordance with safe and proven engineering practices and shall meet or exceed the Department of Transportation Regulations (49 CFR Part 192, Transportation of Natural and Other Gas by Pipelines Minimum Federal Safety Standards) and FS guidance (Forest Service Handbook 2709.11, Special Uses Handbook).

Impacts associated with the onsite construction of wellsites, access roads, flowlines, and ancillary facilities and well drilling and completion would approximate impacts associated with heavy construction and industry. For all three alternatives, hazards would be generally limited to oil company employees and contractors, and probably would not affect the public.

However, to access the project area for construction and operations, project personnel would operate vehicles into and out of the project area. An estimate of the total number of round trips for the project life of each alternative is presented in Table 4-14. Federal, state, county, and multi-use FS roads for public use would be traveled by project construction and operations vehicle traffic. Using statistics for vehicular accidents and an estimated mileage for an average round trip of 50 miles per vehicle, an estimate of the number of accidents, injuries, and fatalities can be developed. Statistics for trucks and commercial vehicles (not specific to oil and gas industry) supplied by the Motor Carrier Information and Analysis Division, Bureau of Motor Carrier Safety are as follows:

Accidents	1.3 per 1,000,000 miles
Injuries	60 per 100,000,000 miles
Fatalities	24 per 100,000,000 miles

Alternative A. An estimated 2,793 round trips would be completed for Alternative A; total mileage at 50 miles per trip is 139,650 miles. Using this mileage, the accident rates for this alterative would be as follows:

Accidents	0.18 per 139,650 miles =	18 percent chance
Injuries	0.08 per 139,650 miles =	8 percent chance
Fatalities	0.03 per 139,650 miles =	3 percent chance

Alternative B. An estimated 30,080 round trips would be completed for Alternative B; total mileage at 50 miles per trip is 1,504,000 miles. Using this mileage, the accident rates for this alternative would be as follows:

Accidents	1.96 per 1,504,000 miles =	196 percent chance
Injuries	0.90 per 1,504,000 miles =	90 percent chance
Fatalities	0.36 per 1,504,000 miles =	36 percent chance

Alternative C. An estimated 77,046 round trips would be completed for Alternative C; total mileage at 50 miles per trip is 3,852,300 miles. Using this mileage, the accident rates for this alternative would be as follows:

Accidents	5.01 per 3,852,300 miles =	501 percent chance
Injuries	2.31 per 3,852,300 miles =	231 percent chance
Fatalities	0.92 per 3,852,300 miles =	92 percent chance

The traffic incident figures for the alternatives indicate that the potential for an accident to occur is about 10 times greater for Alternative B in comparison to Alternative A, and 3 times greater for Alternative C in comparison to Alternative B.

4.13.2 Mitigation Summary

In addition to measures addressed in Appendix A and in the previously listed regulations and standards:

- All project personnel would be required to report to the FS any unusual activity including fires or flowline leaks.

- Use road closures or limited access into specific areas of concern to control motorized access.

4.13.3 Unavoidable Adverse Impacts

The chance of vehicular accidents to occur for Alternatives B and C would exceed 100 percent. The chances of injury would exceed 80 percent and 230 percent for Alternatives B and C, respectively. Chances of fatality would exceed 30 percent and 90 percent for Alternatives B and C, respectively.

A comparison of probable impacts or effects that would result from implementation of the Proposed Action or alternatives is presented in the following discussions of direct and indirect impacts, cumulative impacts, irreversible and irretrievable commitment of resources, and the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity. Comparative analyses were based on information contained in Section 4.0.

5.1 DIRECT, INDIRECT, AND CUMULATIVE IMPACTS

Impacts were determined by the resource specialists for the appropriate resource element. Many of the impacts could be mitigated through the implementation of mitigation measures which would reduce site- or area-specific impacts to acceptable levels. These impacts would be considered mitigable unavoidable adverse impacts. Other impacts could remain at higher levels with mitigation measures applied. These impacts would remain as unavoidable adverse impacts. Cumulative impacts described by resource in Section 4.0 were developed from the assessment of impacts resulting from past land management activities, research findings, and current operations of existing CBM gas field facilities. Resource-specific impacts to NFS lands are compared by alternative in Table 5-1 and are discussed by resource below.

Soils and Geologic Hazards. Comparisons of impacts resulting from implementation of the three alternatives indicates the extent of disturbance to soil resources and surface stability increased on NFS lands within the Study Area by an average multiple of about seven from Alternative A to Alternative B and by an average multiple of about 2.5 from Alternative B to Alternative C (Table 5-1). Application of mitigation measures would reduce acres of lost soil productivity to approximately one-half for the life of the project. Mitigation and sound engineering practice would also reduce impacts related to surface stability, slope, and erosion to essentially zero.

Forty-five acres of existing well site disturbance and 135 acres of existing transportation ROW disturbance were added to the disturbance acreages for the three alternatives to arrive at cumulative impacts. Total acres of existing disturbance plus proposed initial disturbance for the alternatives would be 226 acres (0.5 percent of NFS lands), 451 acres (1.0 percent of NFS lands), and 826 acres (1.8 percent of NFS lands) for Alternatives A, B, and C, respectively (Table 4-3). Application of mitigation measures would reduce acres

TABLE 5-1
COMPARISON OF DIRECT AND INDIRECT IMPACTS ON NFS LANDS FOR THE PROPOSED ACTION AND ALTERNATIVES*

Discipline/Topic	Alternatives					
	A		B		C	
	w/o mit[1]	w/mit[2]	w/o mit	w/mit	w/o mit	w/mit
General						
New well/facility pad (acres)	NA[3]	NA	84	NA	285	NA
New road/flowline ROW (acres)	NA	NA	141	NA	315	NA
New flowline ROW (acres)	46	NA	46	NA	46	NA
Soils and Geologic Hazards						
Soil Profile Development (acres)	46	46	271	271	646	646
Soil Productivity (acres)	46	0[4]	271	112	646	316
Surface Stability Sensitivity (acres)	0.1	0	8.9	0	21	0
Slope Sensitivity (acres)	1.5	0	55	0	246	0
Erosion Hazard Sensitivity (acres)	11.4	0	133	0	375	0
Water Resources						
Stream Crossings (no.)	8		18		55	
Surface Water Quality/Quality	MI	AI	MI	AI	MI	AI
Ground Water Quality/Quality	MI	AI	MI	AI	MI	AI
Air Quality	MI	AI	MI	AI	MI	AI
Vegetation, Timber, and Grazing						
Vegetative Cover (acres)	46	0	271	112	646	316
Wetlands/Riparian Sensitivity (acres)	7.9	0.2	47	1.4	181	5.1
Sensitive Plant Species	MI		MI		MI	
Timber and Grazing	MI		MI		MI	
Wildlife and Fisheries						
Direct Habitat Loss	46	0	271	112	646	316
Big Game Winter Range						
Total at 60% HE[6]	46		2,505		4,132	NSI
Threatened, Endangered, or Candidate Species	NI		NI		NI	
Visual Resources (acres)	1.0	AI	1.0	AI	35	UMI

TABLE 5-1

(Continued)

Discipline/Topic	Alternatives					
	A		B		C	
	w/o mit[1]	w/mit[2]	w/o mit	w/mit	w/o mit	w/mit
Cultural Resources	MI[5]		MI[5]		MI[5]	
Land Use	MI		MI		MI	
Transportation	MI		MI		MI	
Noise	MI		MI		MI	
Recreation Resources	MI		MI		MI	
Non-roaded Area (acres)	17,894		15,590		7,962	
Socioeconomics						
Socio - Direct	MI		MI		UMI	
Indirect	MI		MI		UMI	
Economic - Direct	BI		BI		BI	
Indirect	BI		BI		BI	
Health and Safety	UMI		UMI		UMI	

1 Without mitigation measures applied
2 With mitigation measures applied
3 Not Applicable
4 Zero acres with mitigation measures applied assumes, where necessary, the successful application and maintenance of effective mitigation measures; minor areas may initially or subsequently fail, but will be appropriately mitigated in a timely manner.
5 Direct impacts are mostly mitigable; however, secondary impacts are likely to remain mostly non-mitigable.
BI - Beneficial Impacts
MI - Unavoidable Adverse Impact, Mitigable
UMI - Unavoidable Adverse Impact, Unmitigable
* - The existing situation is not included
AI - Adverse impact -- does not exceed standards
NI - No impact
6 Habitat effectiveness (see p. 4-61 for a definition).

of lost soil productivity from 451 acres to 292 acres and from 826 acres to 496 acres for Alternatives B and C, respectively. Again, mitigation and sound engineering practice would reduce cumulative impacts related to surface stability, slope, and erosion to essentially zero.

Water Resources. Implementation of the three alternatives would result in the crossing of 8, 18, and 55 intermittent streams by the transportation network for Alternatives A, B, and C, respectively (Table 5-1). With increases in stream crossings, the potential for adverse effects on channel configuration and water quality and quantity during periods of flow also increases. Sources of adverse effects are increased sedimentation of streams from soil erosion from disturbed areas, particularly those proximate to the stream, and accidental releases of contaminants during field construction and operations. Immediate and effective responses to any such releases should minimize impacts to surface and shallow ground waters. Proper construction and operation of CBM wells would prevent cross contamination of aquifers, particularly the near surface aquifers which support area water wells.

No adverse impacts on surface or ground water resources have been identified for existing CBM well field facilities and operations within the Study Area. Use of sound engineering practice and the application of appropriate mitigation measures to the construction and operation of additional facilities should minimize adverse impacts.

Air Quality. Locally elevated pollutant levels of dust and vehicle emissions may exist for short periods during construction and some operations activities. Projected emissions for the operations phase of each of the three alternatives are well below the federal and state air quality standards. Use of background air quality conditions for the City of Durango, in combination with projected emissions for the three alternatives, indicates cumulative impacts to air quality in the Study Area would be well below federal and state air quality standards.

Vegetation, Timber, and Grazing. Implementation of the three alternatives would result in the removal of natural vegetation from approximately 46 acres, 271 acres, and 646 acres for Alternatives A, B, and C, respectively. Revegetation of some disturbed areas after construction of facilities is completed would leave 112 acres for Alternative B and 316 acres for Alternative C cleared of vegetation for the duration of the project (Table 5-1). Acres of disturbance to wetlands and riparian areas would be reduced from 7.9 to 0.2 acres for Alternative A, 47 to 1.4 acres for Alternative B, and 181 to 5.1 acres for Alternative C with the application of mitigation measures. Losses of timber acreage and grazing lands would not exceed one percent under any alternative.

Cumulative impacts for cleared vegetation would be the same as those described for disturbed soils detailed above. Cumulative impacts to wetlands, riparian areas, timber, and grazing lands would increase slightly over impacts described for the alternatives above.

Wildlife and Fisheries. Implementation of the three alternatives would result in the loss of wildlife habitat totaling 46 acres, 271 acres, and 646 acres for Alternatives A, B, and C, respectively. Revegetation would restore habitat for Alternatives B and C as described above. For the high sensitivity issue of big game winter range, acres of reduced use, nonuse, and reduced habitat effectiveness increase from Alternative A, to Alternative B, and to Alternative C (Table 5-1). The application of appropriate mitigation measures should reduce the level of impact to big game winter range. Threatened, endangered, and candidate species should not be impacted by any alternative.

The cumulative effects of past land management activities and the current CBM gas development has probably adversely affected elk and mule deer, primarily by reducing habitat effectiveness and areas proximal to roads and facilities.

Visual Resources. Implementation of the three alternatives would result in impacts to 1.0 acre, 1.0 acre, and 35 acres of high visual sensitivity for Alternatives A, B, and C, respectively. The application of appropriate mitigation measures will reduce the impact of visual contrasts for most project facilities. Past land management activities and the current development of CBM field facilities, coupled particularly with the implementation of Alternative C, would result in long-term adverse visual impacts.

Cultural Resources. Implementation of the three alternatives with required mitigation measures applied would not result in any significant impact as described by 36CFR 60.4.

Land Use. No substantial direct impacts would result from the implementation of the three alternatives. Five acres of high land use sensitivity would be impacted by implementation of Alternative C (Table 4-13). Short-term indirect adverse effects from noise, traffic, and dust to nearby residences would particularly result from construction of all alternatives. Such impacts would be proportionally greater for Alternatives B and C over Alternative A.

Transportation. Implementation of the three alternatives would produce an estimated 2,793, 30,080, and 77,046 vehicle roundtrips (50 miles per roundtrip) for Alternatives A, B, and C, respectively. Such activity would proportionally, by alternative, result in increased traffic volumes with direct adverse effects on rates

of road surface deterioration and maintenance requirements. Indirect effects would proportionally, by alternative, also result in increased noise and dust levels to nearby residences and reduced levels of safety for all users of the affected roads.

Noise. Regardless of the alternative, receptor locations greater than approximately 1,000 feet from a noise source would not be adversely effected by project activities. The application of mitigation measures could reduce impacts to a receptor located within 1,000 feet of a noise source to acceptable level depending on site conditions.

Recreation. Direct and cumulative impacts to recreation resources were greatest for Alternative C. These impacts included 1) reduced quality of recreation opportunities due to increased noise, dust, and traffic throughout the Study Area, 2) conflict with a ROS management area which prescribes management for semi-primitive, non-motorized recreation opportunity, and 3) increased access opportunities to much of the Study Area which could enhance dispersed recreation opportunities. The application of mitigation measures would minimize impacts to recreation resources. Indirect adverse impacts for all alternatives would be the short-term effects of noise, dust, and traffic on recreation activities.

Socioeconomics. Adverse and positive direct, indirect, and cumulative effects were identified for the three alternatives. Adverse effects would be mostly indirect impacts on Study Area residents' lifestyle resulting from increased noise, dust, and vehicle traffic. Such impacts would be mostly short-term for Alternatives A and B; however, these impacts would continue in some portion of the Study Area for an estimated seven or more years of field development and the subsequent 37 years that the field would likely be in operation. Positive effects to economic conditions and local tax revenues would increase proportionally by alternative from Alternative A to C.

Health and Safety. Use of the Study Area by field construction and operating personnel and the general public could lead to increased risk of wildfire; however, all would be required to adhere to fire prevention measures in all activities. The potential for pipeline leaks or failure exists; however, all permitted gas pipelines will meet or exceed stringent federal requirements for proven engineering and safety. The chance of vehicular accidents to occur for Alternatives B and C would exceed 100 percent. The chances of injury resulting from such accidents would exceed 80 percent and 230 percent for Alternatives B and C, respectively. Chances of fatality would exceed 30 and 90 percent for Alternatives B and C, respectively.

5.2 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The development and operation of a CBM gas field in the HD Mountains Study Area would involve irreversible and irretrievable commitments of various resources that are either consumed, committed, or lost during the life of the project. Use of many resources is required in the extraction, refinement, and transportation of hydrocarbon energy sources. The irreversible and irretrievable commitments of this project would include the following:

- Lost soil profile development and soil productivity for the life of the project;
- Loss of soil due to accelerated erosion;
- Loss of vegetative cover for areas occupied by facilities;
- Loss of effective wildlife habitat;
- Degradation of visual scenic quality;
- Loss of archaeological or historical resources due to accidental disturbance or mitigation activities;
- Loss of non-roaded area; and
- Loss of rural lifestyle.

5.3 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The local short-term impacts of the project would include current impacts through construction activities which would occur for one year (1991) under Alternatives A, one to three year under Alternative B, and approximately seven years (1991 to 1998) for Alternative C. Long-term project impacts would occur over about 30 to 37 years, depending on the alternative implemented, or until 2021 to 2028.

The major short-term and long-term considerations are as follows:

- Short-term

  - Effects on soils, vegetation, wildlife, and visual resources;

  - Alteration of existing surface and ground water conditions;

  - Effects on air quality;

  - Effects on cultural resources;

  - Noise impacts; and

  - Uses of energy and transportation facilities.

- Long-term

  - Enhanced national security/energy independence through the addition of reserves and production of natural gas;

  - Productive use of public lands and coal deposits;

  - Revegetation of areas occupied by facilities at abandonment/closure;

  - Economic benefits to the private sector; and

  - Tax revenue benefits to the public sector.

The mitigation measures and monitoring requirements that follow could be included in the Conditions of Approval for APDs in addition to those specified in Appendix A, if project approval were granted. The measures and requirements were developed in response to impacts identified in the Environmental Consequences chapter of this EIS (Section 4.0) and through issues identified during the scoping process. They are inclusive of the measures identified by the lessee/operator in the APD. The measures and requirements describe how construction, drilling, and reclamation would be managed to ensure compliance with the applicable lease, Unit Area stipulations, and resource limitations identified during the interdisciplinary analysis. The following measures and requirements are suggested for Alternatives A, B, and C. If deemed necessary, to minimize impacts or in light of new facts, the following measures may be added to, modified, or selectively applied. Determination of final mitigation measures and monitoring requirements will be made by the authorized officer (AO) after consultation with a FS and BLM interdisciplinary team (ID team), who will have made recommendations based on on-the-ground situation analysis.

6.1 SOILS AND GEOLOGIC HAZARDS

- Mulch must be crimped into the soil surface on the contour for reclaimed and seeded slopes up to the slope limit of the crimping equipment.
- Mulched slopes too steep for mechanical crimping must be bound with a sprayed tackifier or covered with a tacked netting, as appropriate, to hold the mulch in place.
- Avoid placement of facilities on unstable slopes or surfaces.
- Conduct detailed geologic and geotechnical studies of sufficient detail to develop site-specific engineering designs, and implement appropriate construction for necessary crossings of areas of slope instability.

6.2 WATER RESOURCES

- Construction near perennial or ephemeral drainageways should contain either vegetation buffers, or temporary settling ponds, at the construction site to contain any erosion and prevent the movement of soils into the drainageways.

- Bradenhead Testing should be conducted pursuant to BLM Conditions of Approval (Appendix A-2).

- Time for construction should be minimized to reduce the possibility of runoff.

- Construction across a stream should incorporate prudent design, including riprap, with sufficient capacity to manage high energy flow associated with thunderstorms and spring runoff.

- Design and implementation of a monitoring network, and the development of a spill contingency and response plan (containment, cleanup, and mitigation of losses).

- Maintenance of access roads.

- Produced water fluid transfer should not occur in the vicinity of perennial or ephemeral drainageways.

6.3 AIR QUALITY

- Comply with all applicable federal and state regulatory requirements concerning permitting of appropriate project facilities.

- Follow manufacturers' specifications for the operation and maintenance of all prime movers at project facilities and project-related vehicles to reduce emissions.

- Operate all vehicle engines and prime movers at facilities to achieve the highest possible fuel efficiency to reduce emissions.

- Water construction areas and roads to the maximum extent practicable to reduce the generation of fugitive dust.

6.4 VEGETATION, TIMBER AND GRAZING

- Restoration of the ground surface, and revegetation of all disturbed areas of soil with approved seed mixes, fertilizer, and mulch

- Salvage of topsoil from well pads for later re-use

- Prevention of erosion, through use of erosion-control devices in disturbed areas, including water bars

- Avoidance of encroachment on streams

- Construction limited to dry conditions to reduce compaction and rutting

- Elimination of noxious weeds on disturbed areas

- Prevention of fires through restrictions on burning and by use of mufflers or spark arresters on all vehicles

- Protection and restorage of existing range improvements, including fences

- Safe handling and storage of fuels, lubricants and other liquids and materials to prevent soils and water contamination

- Trees to be cut shall be designated by the FS and sold

- Control of the use of herbicides

Additional mitigation measures which should be applied include the following:

- The success of revegetation after abandonment would be monitored by the FS, and repeat applications would be required if revegetation is not successful.

- Ensure that the application, storage, and handling of all herbicides meet federal and state requirements.

- Surveys for sensitive plant species shall be conducted prior to ground surface disturbance, and impacts minimized by avoidance of populations or other appropriate mitigations.

- Streams with riparian and/or wetland vegetation would be crossed at right angles by roads and flowlines so that the area of impact would be minimized. Roads and flowlines paralleling streams would not be placed in riparian or wetland areas. Well pads would not be placed in riparian or wetland areas.

- Driving vehicles off approved roads or outside the construction ROWs shall be prohibited.

6.5 WILDLIFE AND FISHERIES

Field Design

- Minimize the number and length of new access roads constructed for the expansion of gas development.

- Where possible, access new wells via spur roads off the existing road system rather than separate primary access roads.

- Adopt a road system with numerous spur roads branching off each primary access road such that all roads beyond each primary access road can be closed to public access via a locked gate.

- Where possible, select noncritical wildlife habitats over critical or important habitats (e.g., big game winter range, turkey roosts, and riparian corridors) for siting roads, flowlines, and

wellpads. Longer roads through noncritical habitats are generally preferred over shorter routes through critical habitats.

- Minimize the number of stream crossings.

- Attempt to maintain a minimum 100-foot zone of undisturbed vegetation between roads and streams to trap erosion, reduce sedimentation, and maintain water quality.

- Following initial surveys to stake ROW alignment and well siting, notify the FS if any prairie dog towns are to be disturbed. The intended disturbance of prairie dog towns on federal or state lands would likely require those towns to be "cleared" for black-footed ferrets. It would be much simpler to avoid any towns.

- Continue to survey for Mexican spotted owls in suitable habitats until a determination is made about their listing.

Construction

- Prohibit construction in critical wildlife habitats during critical seasons. For example, construct roads and drill wells in big game winter range during summer. Restrict drilling in or within 1/4 mile of big game winter ranges from November 30 to April 30, with flexible specific dates to be determined semi-annually (fall and spring) via communications among Amoco, FS, and CDOW personnel based on seasonal conditions and big game habitat use.

- Reduce the area and duration of disturbance, such as minimizing pad size and revegetating pad slopes, road shoulders, and flowline corridors with vegetation beneficial to wildlife.

- Minimize fencing and install fencing that reduces wildlife mortality and restricts wildlife movements while meeting gas company needs. For example, a 38-inch-high top strand with a 12-inch kickspace below is adequate to restrict cattle, yet permits easier wildlife movements.

- Prohibit employees and contractors from bringing dogs onsite or carrying firearms.

Operation

- Close all new roads, including spur roads off existing roads, to public access with locked gates as far down on the road system (i.e., as close to the FS boundary) as possible. Gate locations should be located to use natural topographic features, vegetation, or supplemental barriers to restrict the public from driving around the gates. After seasonal wildlife impacts associated with a new or expanded road system are evaluated, some roads may be seasonally opened to the public during noncritical wildlife periods to better meet recreational and game management goals. Decisions would be made after consultation among Amoco, FS, and CDOW personnel.

- Seasonally close some existing FS access roads (e.g., Sauls Creek Road) to public vehicle use between November 30 and April 30 (Spring Creek Road closure December 26 through April 30) to reduce poaching and harassment of big game on winter ranges. Signed, locked gates should be installed as close to the FS boundary as possible as delineated above. Sign language might consist of "Road closed to public vehicle use between November 30 and April 30 to protect big game on winter ranges."

- Equip all new wells with telemetry to reduce monitoring frequency from daily visits to two to three visits per week.

- Schedule maintenance activities to occur between 1000 to 1400 hours at facilities in important wildlife habitats (e.g., big game winter range) during critical seasons and at facilities that must be accessed by roads through sensitive habitats.

- Prohibit employees and contractors from bringing dogs and firearms to work and prohibit nonauthorized use behind locked gates.

- Continue to implement periodic employee/contractor wildlife awareness programs covering seasonal wildlife requirements and sensitivities, how disturbances affect wildlife, and ways personnel can reduce disturbances.

- Maintain open communications among Amoco, FS, and CDOW personnel to adjust or refine operations in response to changes in seasonal wildlife use patterns.

- Enhance existing big game winter range in suitable undisturbed portions of the Study Area to reduce loss of FS winter range. Use habitat manipulation to convert adjacent habitats in the study area into winter foraging areas. The HABCAP model will be used to evaluate the effectiveness of the manipulations.

- Reduce or eliminate domestic livestock grazing on lands which overlap elk and deer winter range to increase forage availability.

6.6 VISUAL RESOURCES

Strategic Location

- Locate facilities away from prominent topographic features.

- If possible, locations should avoid populated areas, parks, scenic areas, hilltops, and natural or man-made structures. For pipeline and other linear facilities, avoid crossing crests of hills.

- Where possible, facilities should be located where they may be naturally or artificially screened. Ridgelines should be avoided unless adequate vegetation or topographic screening is available.

- For sloping terrain, a multiple-level, terraced facility plan should be considered to minimize excavation and provide a facility that will blend effectively. Near travel routes, facilities should be located partway up slopes to provide a background of topography and/or natural cover where possible. Screen these facilities from highways and other areas of public view to the maximum extent possible with natural vegetation and terrain.

- Where placement of a facility is necessary in a hilltop area, consider locations on the slopes or brow of a hill to allow minimum silhouette or skylining.

- Facilities in general should be strategically placed to make maximum use of existing topography and vegetation for screening. Use the edge effect for facility placement along natural vegetation breaks.

- Facilities should be located at the base of slopes when feasible to provide a background of topography and/or natural cover.

Minimization of Disturbance

- During construction, clearing of land for project facilities or structures should create curvilinear boundaries instead of straight lines and minimize disturbance of the landscape. Grading should be done in a manner which will minimize erosion and conform to the natural topography (FS 1977).

- The clearing of trees and vegetation for the project facilities should be limited to the minimum area required. Feather and thin edges of vegetation.

- To the maximum extent possible, all foliage adjacent to the site should remain undisturbed to provide maximum screening of the installation.

- Brush or small trees cleared and not otherwise disposed of may be spread in a way to provide cover habitat for small mammals, reptiles, and birds. Woody materials should be randomly placed, particularly in downslope fill areas, to conform to adjacent vegetation patterns.

- All nonmerchantable timber and other vegetation material without value should be mechanically chipped and spread in a manner that will aid seedling establishment and soil stabilization.

- Soil which has been excavated during construction and not used should be evenly backfilled into the cleared area or removed from the site. The soil should be graded to conform with the terrain and the adjacent land.

- Dumping of excess material on downhill slopes should be minimized.

- Replacement of earth adjacent to water crossings should be at slopes less than the normal angle of repose for the soil type involved.

- Cut-and-fill slopes should be rounded to break sharp unnatural edges formed at the contact point between the constant-pitch out-slope and the rounded natural landform.

- To reduce the short-term impacts associated with road construction, it is recommended that steps be taken to minimize fugitive dust (i.e., water roads, gravel, 15 mph speed limit).

- During construction, care should be taken to protect all existing vegetative cover, trees and shrubs in particular, at the edge of the right-of-way. Cut-and-fill sections on all access roads should be revegetated with indigenous species or adapted species that match native plant community phenology. Planting should occur at the earliest suitable planting data. All post-construction debris should be removed immediately after construction.

<u>Facility Design</u>

- In general, when practicable, the use of low profile concepts and simplified structures will enhance the overall appearance of the facility. Structures should be single story and of minimum size to satisfy present and future functional requirements.

- Cut-and-fill slopes should be designed to achieve maximum compatibility with the surrounding natural topography. Access roads should be aligned to follow existing grades to minimize cuts and fills.

- Access roads should be provided with side drainage ditches and traverse culverts to prevent soil or road erosion.

- Revegetation efforts should consider creative landscaping practices in highly visible or sensitive areas to enhance the appearance of project facility installation. Consideration should be given to:

  - Mulching cleared cut and fill areas
  - Controlling planting times
  - Furrowing slopes
  - Planting holes on cut/fill slopes
  - Choosing native plant species

- Stockpiling and reusing topsoil
- Fertilizing, mulching, and watering vegetation
- Adding mulch, hydromulch, or topsoil
- Soil retaining matting
- Shaping cuts and fills to appear as natural forms
- Cutting rock areas so forms are irregular
- Designing to take advantage of natural screens (i.e., vegetation, landforms)
- Grass seeding of cuts and fills

- Project signs, ground cover, etc., should be compatible with their surroundings.

- Exterior lighting for project facilities should be adequate for work and for protection of the facilities from sabotage and malicious mischief, and should be acceptable to the landowner.

- Color (hue) of project facilities is most effective within 1,000 ft (Johnson et al. 1970). Beyond that point, the hue becomes indistinguishable and only the value of the color can be expected to have any appreciable effect. When viewed from the shaded side, a facility structure appears as a dark silhouette and generally its color is indistinguishable. Consideration should be given to coloring of facilities to blend with the landscape. This is particularly significant in or near areas of high scenic value. The colors selected for project facilities and structures should be based on the following considerations (Robinette 1973):

    - The colors should be uniform and noncontrasting to blend with the immediate natural environment. The warmest color tones are appropriate for natural settings.

    - Exposed concrete at wellsites should be painted to match soil color.

    - Colors should be selected on the basis of their ability to blend with the land and not the sky.

- Colors that are similar to adjacent colors are most successful in adapting to their environment.

- Paint project facilities somewhat darker than the adjacent landscape to compensate for the effects of shade and shadow.

- Select paint finishes with low levels of reflectivity (i.e., flat or semi-gloss).

- Colors similar to those in the Munsell Soil Color Coding System and displayed on the Standard Environmental Color Chart, prepared by Rocky Mountain Five-State interagency committee, should be considered for all project facilities.

6.7 CULTURAL RESOURCES

- Pursue executing a Memorandum of Agreement (MOA) between FS, State Historic Preservation Officer, Advisor Council, Amoco, and other interested parties.

- Comply with the terms of the MOA if exists among agencies.

- First priority for construction activities is site avoidance. If avoidance is not possible, conduct site protection and data collection and analysis.

- Monitor construction activities with a qualified archaeologist in high sensitivity areas with the potential for buried resources.

- Conduct employee education programs to sensitize employees to the cultural and legal status of significant cultural resources.

- Restrict access into, and/or patrol, some highly sensitive areas to minimize vandalism and unauthorized artifact collection.

6.8 LAND USE

- Comply with all regulatory agency and landowner permit and lease requirements concerning general agricultural and other land use issues.

- Locate project facilities on the edges of irrigated and non-irrigated agricultural land to the maximum extent practicable to reduce direct and indirect effects on agricultural resources and operations.

- Reduce speeds of oil and gas trucks and contractor vehicles when approaching and passing residential dwellings adjacent roads.

- Minimize crossings or other direct effects on water shed restoration facilities; agricultural irrigation facilities, including water canals, ditches, pipelines; and other water conveyance systems to the maximum extent practicable, or provide for their protection to allow them to operate as designed.

- If facilities (e.g., fences, gates) are damaged, repair or replace the facility according to landowner requirements.

- Minimize project-related construction equipment and vehicle movements off specific access roads to avoid disturbance of agricultural and other land.

- Schedule concentrations of project traffic, such as truck convoys, or heavy or wide loads, to avoid periods of expected heavy traffic flows due to recreation events (e.g. hunting seasons, weekend periods).

- If well construction or drilling activities occur during deer/elk hunting season or elk migration, special signing to warn public of construction, speed limit signing, and a gate road from start of new construction should be implemented.

6.9 TRANSPORTATION

- Complete watering or other approved chemical dust-abatement procedures on heavily-used dirt and gravel roads to reduce fugitive dust emissions to the maximum extent practicable.

- Provide instructions to company and contractor workers to obey speed limits and other related legal requirements.

- Provide instructions to company and contractor personnel to comply with road capacity ratings.

- For state and county roads to be used, notify the respective administrations department.

- Require company and contractor personnel to utilize adequate signing, barriers, flag-persons, and other measures, including detours, to control traffic where significant project activities occur on or adjacent to roads.

- Adequately maintain project-related vehicles according to manufacturer's specifications, primarily with respect to mufflers; include company and contractor vehicles in this mitigation effort.

- Consolidate project-related vehicle trips to the maximum extent practicable to reduce traffic rates on regional access roads.

- Avoid rutting of wet dirt access roads to the maximum extent practicable by avoiding such roads, if possible, and adding gravel to roads, if needed.

- Remove all project-related deep ruts in dirt access roads at appropriate times.

- Use high capacity asphalt-surfaced roads to the maximum extent practicable for project-related traffic to reduce direct effects on gravel and dirt roads, and to reduce the generation of fugitive dust.

6.10 NOISE

In cases where the facilities are closer than 1,000 ft to a sensitive receptor, the following mitigation measures should be utilized separately (or in any combination) to reduce impacts to less than 55 dBA measured at the nearest receptor:

- Muffling. Several different grades of muffling systems have been developed for the types of compressors and pumping units used in the San Juan Basin Coal Degas Project areas, ranging from standard mufflers to hospital grade mufflers and supercritical muffling systems. These muffling systems can generally reduce sound levels by approximately 4 to 8 dBA. Maintenance of project-related construction equipment, truck, and automobile muffling systems to manufacturer's specifications should also be completed. In addition, upgraded muffling systems on drilling rigs should be utilized.

- Sound Barriers. The construction of sound barriers between the source and the receptor has been shown to reduce sound levels. The magnitude of the reduction depends on the type of material used, the distance from the source to the barrier, the height of the barrier, and the distance between the source and the receptor. The material used for constructing the barrier must be selected so that the transmission of sound through the barrier is much less than that diffracted over the top. In general, this can be achieved by ensuring that the mass of the barrier material is at least:

    - 1.3 lbs/ft^2 for an attenuation of 5 dB.
    - 2.3 lbs/ft^2 for an attenuation of 10 dB.
    - 4.0 lbs/ft^2 for an attenuation of 15 dB.

Specific types of sound barriers which could be used include the following:

- Sound barriers with or without insulation surrounding compressors and pumping units

- Planted tree barriers, specifically using fast-growing species such as the Lombardi poplar, around compressors and pumping units

- For short-term use, strategic placement of solid obstacles at appropriate locations in the areas of compressor stations and pumping units

In addition to these types of barriers, it may be possible to enclose compressors and injection well facilities inside buildings similar to the building currently housing the Amoco San Juan Basin McCaw injection well facilities. Use of this building is currently resulting in substantial noise reductions.

- Existing Topography. The existing topography and vegetation of the project area can also be used to reduce noise generated by proposed project facilities. Hills, trees, and other vegetation have been shown to be effective in reducing noise levels at sensitive noise receptors. Reductions on the order of 10 dBA, depending on the frequency of the noise source, the geometry of the proposed location, and the type and thickness of the vegetation barrier (Edison Electric Institute 1978) can be achieved.

6.11 RECREATION

- Moratorium periods that would temporarily restrict construction activities and well operation activities during big game hunting seasons.

- If well construction or drilling activities occur during deer/elk hunting season or elk migration, special signing to warn public of construction speed limit signing, from start of new construction, should be implemented.

- Some year-round closures to public use may be implemented.

- Enforcement of road closure requirements to prevent unauthorized use of the access roads.

6.12 SOCIOECONOMICS

Mitigation measures identified under the sections on Visual Resources (6.8), Land Use (6.5), Transportation (6.9), Noise (6.10), and Recreation (6.11), if successfully implemented, would reduce the socioeconomic impacts associated with each alternative. In addition, for Alternatives B and C, a public information program which would inform residents of areas adjacent to NFS lands and along Study Area access roads,

and users of NFS lands within the Study Area about the nature and duration of activities, could reduce dissatisfaction and conflict during the field development phases of these alternatives.

6.13 HEALTH AND SAFETY

- All project personnel would be required to report to the FS any unusual activity including fires or flowline leaks.
- Use road closures or limited access into specific areas of concern to control motorized access.

7.1 INTRODUCTION

An Environmental Impact Statement (EIS) must be prepared when a federal government agency considers an action within its jurisdiction that may result in significant impacts to the human environment. An EIS aids federal officials in making decisions by presenting the environmental effects of a proposed project and its alternatives. The first step in preparing an EIS is to determine the scope of the project, the range of alternative actions, and the impacts to be included in the document.

The Council on Environmental Quality regulations (40 CFR, Parts 1500-1508) require an early scoping process to determine the significant issues related to the proposed action and alternatives that should be addressed in the EIS. The principal purpose of the scoping process is to identify important issues, concerns, and potential impacts requiring detailed analysis in the EIS and to eliminate insignificant issues and alternatives from detailed analysis. Scoping makes the EIS process more efficient by reducing the time spent on unimportant areas while focusing on the important ones.

7.2 PUBLIC PARTICIPATION

The San Juan National Forest Land and Resource Management Plan (Forest Plan), completed in September of 1983, contains a projection of expected oil and gas drilling and production activities and describes the environmental effects of these anticipated activities. The coalbed methane gas project, proposed by Amoco Production Company, is expected to result in site-specific environmental effects which require a more detailed analysis of project design, mitigation, and resultant environmental consequences.

Scoping for this project began on November 3, 1988 when a scoping document was mailed to 70 interested publics and made available at the Pine District office. The document described the existing situation regarding coalbed methane gas development in the HD Mountains on the Pine District and discussed the reasonably foreseeable future for gas development. The public was asked to describe their concerns. Along with the scoping document, newspaper articles on the same subject appeared in the Durango Herald and Pine River Times in mid-November 1988. As a result, the Forest Service received 41 written responses and a petition signed by 51 individuals.

Further public notification on gas development and the public scoping process was provided in a Forest Service insert to the Durango Herald and Pine River Times in late January 1989 and early March 1989, respectively. An additional but similar insert was made in the Pine River Times in late March 1989.

As a result of the public responses and Forest Service and BLM concerns, the District Ranger concluded that an EIS on coalbed methane gas development should be prepared. A Notice of Intent to Prepare an Environmental Impact Statement (EIS) was published in the Federal Register on April 18, 1989. In addition, a letter from the Forest Service to interested publics announcing the intent to prepare an EIS was mailed on April 25, 1989 to 92 individuals, organizations, and businesses.

The late April news release and letter notified the public of a May 4, 1989 public scoping meeting which was to discuss issues and concerns for the EIS on coalbed methane gas development in the HD Mountains. Subsequent newspaper articles and a Letter to the Editor from Mark Rinnert of the San Juan Citizens Alliance on the same subject were published in the Pine River Times on April 27 and May 4, and in the Durango Herald on April 30 and May 4.

A public scoping meeting was held on May 4, 1989 in Bayfield, Colorado to discuss public issues and concerns on coalbed methane gas development in the HD Mountains for the EIS. About 20 to 25 members of the public attended and participated in the meeting. Because of public comments on the short notice for this scoping meeting and their lack of preparation time, a second public scoping meeting was scheduled for mid-June 1989. The minutes of this May 4 meeting were distributed to all who attended.

A newspaper article reporting the proceedings of the first public meeting was printed in the Pine River Times on May 11. After a date (June 15) was agreed to by all parties, the Forest Service published Public Notices in the Durango Herald, the Pine River Times, and the Pagosa Springs Sun in mid-May 1989 to allow time for the public to prepare for the second meeting. The Public Notice was also posted at the Bayfield Post Office from May 15 to June 17, 1989. On May 16, the Pine District Ranger and several members of the public (i.e., San Juan Citizens Alliance) met, as agreed to at the first public meeting, to prepare the agenda for the second public meeting. The Forest Service also agreed to have representatives of Woodward-Clyde Consultants, who were helping prepare the EIS for the Forest Service and BLM, attend the second public meeting. Additionally, newspaper articles announced the June 15 meeting in the Pine River Times and Durango Herald throughout early and mid-June.

The second public scoping meeting was held on June 15, 1989, in Bayfield, Colorado. Approximately 35 to 40 members of the public attended and participated. Issues and concerns for the EIS on coalbed methane gas development in the HD Mountains for 1990 and beyond were taken. The public was also asked to comment on two Environmental Assessments (EA) that were to be prepared in 1989 to evaluate the development of six gas wells in the HD Mountains. Like the first meeting, the minutes of the June 15 were distributed to all who attended.

As a result of the two public meetings, 16 written responses were received on the EIS. An additional 16 responses directed at the EAs have also been analyzed and included in the issues and concerns which are summarized in Chapter 1 of this document.

7.3 PUBLIC INVOLVEMENT

During preparation of the draft EIS for the proposed project, the Forest Service communicated with and received input from many federal, state, county, and local agencies; elected representatives; environmental and citizens groups; industries; and individuals. Many of these people responded to the Scoping Statement. The following agencies, groups, and individuals have provided input and/or will receive copies of the draft EIS.

7.3.1 Federal Government Agencies

Regional Forester (15 copies)
Rocky Mountain Regional Office
Box 25127
11177 W. 8th Street
Lakewood, CO 80225

USDI Bureau of Land Management
18th & C N.W.
Washington, DC 20240

State Director
USDI Bureau of Land Management
2850 Youngfield Street
Lakewood, CO 80215

USDI Bureau of Land Management
2465 So. Townsend
Montrose, CO 81401

Federal Agency Liaison Division (5 copies)
Office of Federal Activities
Environmental Protection Agency
Mail Code A-104, Room 2119
401 M. Street, SW
Washington, DC 20460

Director, Environmental Project Review (18 copies)
U.S. Department of the Interior
Interior Bldg., Mailstop 4239
Washington, DC 20240

Mr. David E. Ketcham, Director (5 copies)
Environmental Coordination Staff
USDA Forest Service
South Bldg., 12 and Independence Ave. SW
Washington, DC 20250

Assistant Secretary for Occupational Safety & Health
U.S. Department of Labor
200 Constitution Ave., NW Room S-2315
Washington, DC 20210

Assistant Secretary for Mine Safety and Health
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EIS Review Coordinator (3 copies)
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999 18th Street
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Denver, CO 80202-2405

Regional Director
USDI Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, CO 80225

U.S. Army Corps of Engineers
Attention: Mr. Grady McNure
Unit 4, Room 211
764 Horizon Drive
Grand Junction, CO 81506

White River National Forest
Box 948
Glenwood Springs, CO 81602

Pike and San Isabel National Forest
1920 Valley Drive
Pueblo, CO 81008

7.3.2 State Government Agencies

Colorado State Clearinghouse (15 copies)
Division of Local Government, DLA
1313 Sherman Street
Denver, CO 80203

Colorado State Archaeologist
Office of Archaeology and Historic Preservation
1300 Broadway
Denver, CO 80203

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151 E. 16th
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7.3.3 Local Governments

Archuleta County Commissioners
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Pagosa Springs, CO 81147

Bayfield Board of Trustees
11 West Mill St.
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Ignacio Town Board
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Ignacio, CO 81137

La Plata County Commissioners
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Durango, CO 81301

La Plata County Open Space Commission
County Courthouse
1060 E. Second Ave.
Durango, CO 81301

La Plata County Planning Commission
County Courthouse
1060 E. Second Ave.
Durango, CO 81301

Southern Ute Indian Tribe
General Offices
Ignacio, CO 81137

Bayfield Public Library (2 copies)
15 E. Mill
Bayfield, CO 81122

Ruby M. Sisson Memorial Library (2 copies)
P.O. Box 849
Pagosa Springs, Co 81147

Ignacio Library (2 copies)
Town Hall
Ignacio, CO 81137

Durango Public Library
1188 E. Second Ave.
Durango, CO 81301

(4 copies)

7.3.4 Environmental Groups

Colorado Environmental Coalition
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Denver, CO 80203-3518

Sierra Club Legal Defense Fund
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Denver, CO 80202

San Juan Greens
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San Juan Citizens Alliance
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7.3.5 Others

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7.4 LIST OF PREPARERS

Table 7-1 lists the principal players involved with writing and reviewing this EIS.

TABLE 7-1

LIST OF PREPARERS

Name	Responsibility	Qualifications
<u>Forest Service</u>		
Dick Bell	Project Leader	AAS Forestry; BS Forest Management 26 years FS
Bob Dettmann	Timber/Vegetation Resource Review	BS Forest Management 15 years FS
Ron Klatt	Range Resource Review	BS Business Admin 16 years FS
Mike Burke	Geotechnical Engineering Resource Review	Registered Professional Engineer BS Geological Engineering 10 years FS, 1½ private
Katherine Foster	Resource Hydrology & Air Quality Review	BS FS Hydrology Specialty 20 years FS
Richard Ostergaard	Visual Management Resource Review	BLS Landscape Architect 20 years FS
Gary Matlock	Cultural Resources Resource Review	BA Anthropology 10 years NPS 7 years BLM, 4 years FS
Dave Cook	Wildlife Resource Review	BS Wildlife Management 29 years FS
Michael Johnson	Overall Project Review	BS Resource Conservation MS Forest Hydrology 14 years FS
James White	Engineering/Transportation Planning Resource Review	Registered Professional Engineer BS Civil Engineering MS Civil Engineering 10 years Highway Dept. 6 years BIA, 10 years, FS
Jim Powers	Social and Economic Resource Review	BS Forest Management MS Forest Resource Management 9 years FS
<u>Bureau of Land Management</u>		
Mark Hollis	BLM Project Leader Resource Review	BS Biological Science 23 years BLM
Jim Lovato	Petroleum Engineering Resource Review	BS Geological Engineering 6½ years BLM 1 year USGS

TABLE 7-1
(Continued)

Name	Responsibility	Qualifications
Dennis Murphy	Hydrology Resource Review	AA Business Management BS Forestry/Watershed 12 years BLM
Kent Hoffman	Fluid Geologist Resource Review	BS Geology 6 years BLM
Don Englishman	Environmental Resources Resource Review	BFA Art Education MS Geology 7 years USGS 7 years BLM
<u>Colorado Division of Wildlife</u>		
Gary Skiba	Wildlife Resource Review	BS Wildlife Biology MS Wildlife Biology 3 years CDOW 4 years private
<u>Consultant Interdisciplinary Team</u>		
<u>Woodward-Clyde Consultants</u>		
R.W. Bell	Interdisciplinary Team Leader; Project Manager Soils and Geological Hazards	BA Distributed Major Biology, Geology, and Chemistry 3 years graduate studies in Soil Science 13 years consulting
Robert Scott	Visuals, Recreation, Land Use, and Transportation	BS Urban Recreation Administration and Parks Design MLA Landscape Architecture and Environmental Planning 17 years consulting
Jeffrey Dawson	Vegetation, Timber, Range Resource	BS Biology MS Botany 10 years consulting
Mark Asoian	Air Quality/Noise	BS Meteorology 10 years consulting
Robert Montgomery	Water Resources	BS Fisheries and Wildlife MS Resource Development PhD Civil Engineering 11 years consulting
Don Bartow	GIS Coordinator	BS Mining Engineering BS Mechanical Engineering 6 years consulting
William Killam	Cultural Resources	BA Anthropology/Sociology and Psychology 10 years consulting

TABLE 7-1
(Continued)

Name	Responsibility	Qualifications
Western Ecosystems, Inc.		
Rick Thompson	Fish and Wildlife	BS Wildlife Research MS Zoology and Physiology 13 years consulting
Planning Information Corporation		
George Blankenship	Socioeconomics	BA Social Work BS Anthropology MS Urban & Regional Planning 11 years consulting
Archaeological Consultants		
Robert Biggs	Cultural Resources	BA Anthropology 10 years consulting

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A-WEIGHTED - A weighting function applied to the noise spectrum which approximates the response of the human ear.

ALLUVIAL PLAINS - Flood plains produced by the filling of a valley bottom and consist of fine mud, sand or gravel.

ANIMAL UNIT MONTH (AUM) - The amount of forage necessary for the sustenance of a 1,000-lb dry cow in maintenance or gestation, or five sheep, for 1 month.

ASPECT - The direction that a slope faces.

BARITE - (BaSO4) A mineral used to increase the weight of the drilling mud.

BENTONITE - A naturally occurring clay, used to keep the cuttings in suspension as they move up the hole.

BLOOIE LINE - The discharge line containing wastes and cuttings in either oil or gas drilling operations.

BLOOIE PIT - An open pit collecting the cuttings and waste from the blooie discharge line.

BRADENHEAD TESTING - The bradenhead is the portion of the wellhead that is in communication with the annular volume between the surface casing and the next smaller casing string. Conceptually, if there is positive pressure at the bradenhead, this indicates that a casing leak or an inadequate cement job could exist on a well.

BRINE - A highly saline solution.

CAMBRIAN - The oldest of the periods of the Paleozoic Era; also the system of strata deposited during that period.

CARBONACEOUS - Coaly; pertaining to, or composed largely of, carbon.

CASING - Steel pipes of varying diameter and weight which are joined together by threads and couplings at the well. Casing is "run" into the well bole for the purpose of supporting the walls of the well and preventing them from caving in. Surface casing is installed from the ground surface to approximately 250 feet, production casing is run to the total depth of the well (smaller diameter pipe than surface casing), cemented in place and latter perforated for production.

CHRISTMAS TREE - A collection of valves, located at the top of casing, from which tubing in the well is suspended.

CLEAN BURN UNITS - A facility which uses a clean-burning fuel (i.e. natural gas). This is usually a part of Best Available Control Technology (BACT).

CLEAT - In a coal seam, a joint or system of joints along which the coal fractures.

COLLUVIUM - A general term applied to loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity. Talus and cliff debris are included in such deposits.

CONNATE WATER - Water entrapped in the interstices of a sedimentary rock at the time the rock was deposited.

CRETACEOUS - The third and latest of the periods included in the Mesozoic Era; also the system of strata deposited in the Cretaceous Period.

CULTURAL RESOURCES - Remains of human activity, occupation, or endeavor, as reflected in sites, buildings, artifacts, ruins, etc.

CUTTINGS - Fragments of rock dislodged by the bit and brought to the surface in the drilling mud.

DEPTH TO COAL PAY - The depth below the ground surface of a potential economic coal unit.

DEPTH OF BURIAL - The depth below the ground surface and/or thickness of overlying stratum over a particular rock unit of geologic interest. Coals buried at a depth of more than 4,000 feet do not have the flow capacity needed for economic development.

DEWATERING - The act of removing water.

DRILLING - The operation of boring a hole in the earth, usually for the purpose of finding and removing subsurface formation fluids such as oil and gas.

DRILLING FLUIDS - The circulating fluid used to bring cuttings out of the wellbore, cool the drill bit, provide hole stability, and pressure control.

DRILLING RIG - The derrick, draw-works and attendant surface equipment of a drilling or workover unit.

EYRIE - The nest of birds of prey.

FAN - An accumulation of debris brought down by a stream descending through a steep ravine and debouching in the plain beneath, where the detrital material spreads out in the shape of a fan, forming a section of a very low cone.

FEDERAL CANDIDATE SPECIES - Sensitive wildlife species currently under consideration for addition to the threatened or endangered species list.

FLARE - An arrangement of piping and a burner to dispose of surplus combustible vapors, usually situated around a gasoline plant, refinery, or producing well.

FRACTURED - Fissured, broken, or cracked. See also Hydraulic Fracturing.

GAME MANAGEMENT UNIT (GMU) - Colorado is divided into approximately 150 geographic areas called Game Management Units. Game species are managed on a unit specific basis.

HABITAT - A specific set of physical conditions that surround a single species, a group of species, or a large community. In wildlife management, the major components of habitat are considered to be food, water, cover, and living space.

HERPETOFAUNA - Reptiles and amphibians.

HYDRAULIC FRACTURING - A method of stimulating production by increasing the permeability of the producing formation.

HYDROCARBONS - Organic compounds of hydrogen and carbon, whose densities, boiling points, and freezing points increase as their molecular weights increase. Although composed only of carbon and hydrogen, hydrocarbons exist in a great variety of compounds, owing to the strong affinity of the carbon atom for other atoms and itself. The smallest molecules are gaseous; the largest are solids. Petroleum is a mixture of many different hydrocarbons.

HYDRIC SOILS - Saturated soils.

HYDROGEOLOGICALLY CONNECTED - The connection of two or more hydrologic systems, usually refers to separate aquifers in which water can pass and exchange with other aquifers.

HYDROPHYTIC - Water-loving; ability to grow in water or saturated soils.

IMPACT - The results of an action on the environment; the impact may be primary (direct) or secondary (indirect).

JOINT PATTERNS - Patterns of fractures in rock, generally vertical or transverse to bedding, along which no appreciable movement has occurred.

K-FACTOR - Soil erodibility factor.

LENTICULAR - Shaped approximately like a double convex lens.

LITHOLOGY - The physical characteristics of a rock, generally as determined megascopically or with the aid of a low-power magnifier.

LOGGING TOOL - Electric tools which are able to be lowered down a well bore by wire cable and are capable of taking measurements of the physical properties of the rock formations downhole (i.e. resistivity, self-potential, gamma-ray, intensity, or velocity). The data is recorded and displayed on well logs which aid in defining physical rock characteristics such as lithology, porosity, pore geometry, and permeability.

MANAGEMENT INDICATOR SPECIES - Those species that are commonly hunted or whose habitat requirements and population changes are believed to indicate effects of management activities on a broader group of wildlife species in the ecological community.

MITIGATION - The abatement or reduction of an impact to the environment by 1) avoiding a certain action or parts of an action, 2) employing certain construction measures to limit the degree of impact, 3) restoring an area to preconstruction conditions, 4) preserving or maintaining an area throughout the life of a project, or 5) replacing or providing substitute resources to the environment.

MULTIPLE USE - Harmonious use of land for more than one purpose; i.e. grazing of livestock, wildlife production, recreation, watershed and timber production. Not necessarily the combination of uses that will yield the highest economic return or greatest unit output.

NON-RANGE - Areas on the National Forest which are not suitable for livestock grazing due to low forage production, steep slopes, dense brush, or other reasons.

NOTICE OF REVIEW SPECIES - A species that is being considered as candidates for listing as either endangered or threatened under the Endangered Species Act of 1973, as amended.

ONE HUNDRED YEAR FLOOD - A hydrologic event with a magnitude that has a recurrence interval of 100 years.

PEIDMONT - Lying or formed at the base of mountains.

PERFORATIONS - Holes that are made through the casing and cement, and extend some distance into the production zone.

Ph - The negative logarithm of the concentration of the hydrogen ion in gram atoms per liter, used in expressing both acidity and alkalinity. pH values range from 0 to 14, 7 indicating neutrality, numbers less than 7 increasing acidity, and numbers greater than 7 increasing alkalinity.

PLUG - Any object or device that serves to block a hole or passageway, as a cement plug in a borehole.

PRIMARY RANGE - Areas where the majority of livestock grazing is concentrated, due to high forage production, easy accessibility, nearby water sources, or other reasons.

PROPPANTS - Sandgrains, aluminum pellets, glass beads, or similar materials used in hydraulic fracturing. When injected into the production formation, these materials leave channels allowing gas to flow through them into the well.

QUATERNARY - The younger of the two geologic periods or systems in the Cenozoic Era.

RARE OR SENSITIVE SPECIES - Species which have no specific legal protection under the Endangered Species Act as threatened or endangered species, but which are of special concern to agencies and the professional biologic community due to low populations, limited distributions, on going population decline, and/or human or natural threats to their continued existence.

RESERVE PIT - Mud pit in which a reserve supply of drilling fluid is stored. The "reserve pit" can be used as a waste pit.

REST ROTATION GRAZING SYSTEM - A grazing system in which one of several pastures in an allotment or group is "rested" (not grazed) each year, with each pasture being rested in turn.

RIPARIAN - Situated on or pertaining to the bank of a river, stream, or other body of water. Normally used to refer to the plants of all types that grow along or around springs.

SCOPING - A term used to identify the process for determining the scope of issues related to a proposed action and for identifying significant issues to be addressed.

SCREENED - The depth at which a well screen has been placed on a well. A well screen allows fluids to enter the well casing.

SECONDARY RANGE - Areas where livestock grazing occurs but at lower intensities than primary range, due to less favorable conditions of forage production, terrain, distance from water source, or other factors.

SECONDARY SUCCESSION - The process by which ecosystems recover toward pre-existing conditions after removal of a disturbance, such as the recovery process of a forest after a fire.

SEDIMENT - Soil or mineral transported by moving water, wind, gravity, or glaciers, and deposited in streams or other bodies or water, or on land.

SENSITIVITY LEVELS - A measure of people's concern for scenic quality.

SLOPE - The degree of deviation of a surface from the horizontal.

SLUG TESTS - A test used to calculate hydraulic conductivity, transmissivity, and the storage coefficient (i.e. the wells potential yield).

STORAGE COEFFICIENT - The volume of water released from storage in a vertical column of 1 sq. ft. when the water table or other piezometric surface declines one foot.

TERTIARY - The older of the two geologic periods comprising the Cenozoic Era; also the system of strata deposited during that period.

THREATENED OR ENDANGERED SPECIES - Animal or plant species that are listed under the Federal Endangered Species Act of 1973, as amended (federally listed), or under the Colorado or New Mexico Endangered Species Act (state listed).

TOE-SLOPE - The most distant part of a landslide; the downslope edge of a landslide or slump.

TOTAL DISSOLVED SOLIDS - A term that describes the quantity of dissolved material in a sample of material.

TOTAL SUSPENDED SOLIDS - A term that describes the quantity of solid material in a sample of material.

TRANSMISSIVITY - The rate at which water is transmitted through a unit width of aquifer under a hydraulic gradient.

UNIONIZED AMMONIA - A species of nitrogen that is toxic to aquatic life.

VENT - An opening in a vessel, line, or pump to permit the escape of air or gas.

VISUAL ABSORPTION CAPABILITY - The relative ability of a landscape to accept management practices without affecting its visual characteristic. The capability to absorb visual change. A prediction of how difficult it will be for a landscape to meet recommended VQOs.

VISUAL QUALITY OBJECTIVES - Descriptions of a different degree of alteration of the natural landscape based upon the importance of aesthetics.

WALKING BEAM PUMPING UNIT - A unit consisting of a pump jack and engine which is used to lift the produced stream (water and natural gas) from the production zone, allowing gas to flow by reducing the hydrostatic pressure on top of a rock unit (i.e. coals).

WELL LOGGING - A logging truck equipped with various electronic logging tools and a computer which goes out to a well site after drilling operations are completed. The data from the logging tools are recorded on film and digitally stored in the on-site computer. The logging engineer generates printed well logs for use in analyzing the stratigraphic units traversed by a borehole.

WELLBORE - The hole made by the drilling bit.

WELLHEAD - The equipment used to maintain surface control of a well. It is formed of the casing head, tubing head, and Christmas tree. Also refers to various parameters as they exist at the wellhead, such as wellhead pressure, wellhead price of oil, etc.

APPENDIX A
FS AND BLM STANDARD CONDITIONS/ MITIGATION MEASURES

APPENDIX A-1

APPENDIX A-1

PINE DISTRICT
SAN JUAN NATIONAL FOREST

STANDARD PLAN OF OPERATION
NATURAL GAS AND PRODUCED WATER GATHERING
PIPELINES

A. Administration

1. The permittee will have a representative, designated in writing, readily available and authorized to receive notices and take action related to performance under terms of the permit.

2. The Forest Service will provide a full-time liaison officer with delegated authority to administer the provisions of the permit.

3. Construction activities will be limited to dry soil conditions during the period July 15 and November 15.

4. Both pipelines are required to be placed in the same excavation at the same time.

B. Flagging and Staking

During the final survey of the pipeline, the centerline of the pipeline will be staked and flagged. Station numbers of the survey will be written on each lath or hub. A stake will be placed every 200 feet.

During clearing and grading, stakes will be moved to the edge of the right-of-way and will be moved back to the centerline of the ditch after the equipment has passed.

C. Visual Resource Management

1. Where trees and brush are encountered, the right-of-way edge will be feathered. Feathering is considered to be removal of trees and/or brush outside the right-of-way clearing limits to reduce the lineal appearance of the project. The Forest Service will designate on the ground the trees and brush

outside the right-of-way required to be removed. The permittee will notify the Forest Service 10 working days prior to clearing operations beginning.

2. Slash created as a result of this project will be hand piled to a maximum pile size of 10 feet in diameter, 8 feet in height. Grubbing stumps are required only where needed for passage of project vehicles. Grubbed stumps will be disposed of in a pit or pits designated by the Forest Service.

3. Sagebrush and other low-lying brush species in open meadowlands will be removed from the right-of-way in a manner which does not disturb the grass/forb community. It is recommended that a "brush hog" be used to achieve this end result.

4. All disturbed areas of soil, caused by this project will be revegetated. The seed mixture is:

Smooth Brome - Manchar variety	8 lbs/acre
Crested Wheatgrass - Nordan variety	4 lbs/acre
Intermediate Wheatgrass - Oahe variety	4 lbs/acre
Pubescent Wheatgrass - Luna variety	4 lbs/acre
	20 lbs/acre

The seed mixture will be applied with 100 pounds per acre of 38-12-0 fertilizer when seeding takes place. Drilling of the mixture will be utilized where feasible. Broadcast seeding will be utilized on areas where drilling is not feasible at a rate double the amount specified for drilling and the seed covered.

5. Mulch will be applied on slopes greater than 10 percent on sustained grades of 100 feet or longer where disturbed by activities of this project.

6. All above-ground structures will be painted with the appropriate Standard Environmental Colors established by the Rocky Mountain Five-State Interagency Committee.

7. After backfilling of the ditch, final leveling will be done and the proper crown constructed to allow for settling of the ditch.

D. Access

1. Construction of new permanent access roads will not be permitted. The only permanent access will be on existing Forest Development Roads.

2. Aggregate surfacing material on Forest Development Roads shall not be contaminated as a result of activities of this project. If contamination occurs, the permittee will be notified in writing by the Forest Service and rehabilitation measures necessary to correct the contamination will be specified.

3. Where the pipeline excavation crosses a Forest Development Road, the road prism will be reconstructed to its original configuration, including compaction to 95 percent AASHTO T-99, surfacing material replaced in kind, and each layer compacted to a density of at least 95 percent of maximum density, as determined by AASHTO T-99.

4. All temporary roads will be confined to the right-of-way.

5. Following construction, the permittee shall construct any vehicle barriers deemed necessary by the Forest Service.

6. All Forest Development Road crossings will be marked with danger warning signs and lights during construction.

E. Fire

A muffler or spark arrester satisfactory to the Authorized Officer shall be maintained on the exhausts of all trucks and tractors or other internal-combustion engines used in connection with this project.

F. Blasting

The permittee, its personnel, contractor, or contractor's employees shall perform all work with explosives in such a manner as not to endanger life or property in accordance with all state and federal regulations.

G. Restoration and Clean Up

1. Construction activities will be limited to dry soil conditions to minimize compaction and rutting.

2. All soil disturbed as a result of this project will have erosion control devices installed where appropriate. Frequency of waterbar spacing will be dependent on the slope of the lands and are shown below:

Slope	Spacing Internal Feet
0-2	0
2-5	100
6-10	50
10+	40 to 25

Waterbars will be started and finished in vegetation and constructed at grades at 2 percent or more.

H. Hydrostatic Test

Water (of equal or better quality than nearby streams or rivers) will not be obtained from National Forest lands. Water will be pumped up or down the pipeline from points where it can be obtained. The testing procedure will not contaminate the water. Sites used to remove the water will be designated on the ground by the Forest Service and developed to the standard necessary to adequately dispose of the water.

I. General

1. The permittee is responsible for protecting existing improvements along the right-of-way and make timely restoration of any improvements.

2. A clean up crew will pick up all trash or litter on the right-of-way when construction operations have been completed. Such debris will be disposed of at an approved sanitary landfill.

3. The permittee shall locate, handle and store gasoline, oil, lubricants, other liquids or materials, and trash in a manner so as to prevent them from entering into or contaminating water sources and soils.

Equipment oil changes will be conducted in such a manner as to prevent used oil from being drained openly onto the ground. Oil drain catch pans will be required. Used oil containers will be disposed of in an approved manner in an approved sanitary landfill, oil recycling catch or other approved method.

4. Fences cut as a result of any phase of this operation will be braced, and gates installed to prevent passage of livestock. At the completion of construction or any other disturbance, fences will be rebuilt to the original design.

5. Before any construction camp, borrow pit, storage or service area is operated on National Forest lands, written authorization shall be obtained from the Forest Service.

J. Operations

During all operation phases, should a pipeline leak, break, or experience other types of failures, the District Ranger will be notified.

APPENDIX A-2

CONDITIONS OF APPROVAL
COALBED METHANE COMPLETIONS

1. A cement bond log will be required should cement fail to circulate to surface on surface and production casing strings. File one copy of the log run, should cement fail to circulate.

2. Minimum pressure testing requirements are 2000 psi for ram type BOPE and 1500 psi for annular BOPE.

NOTE: You are cautioned to consider your mud program in connection with surface pressure control equipment when drilling into and beyond the Fruitland Formation.

3. File water analysis of the Fruitland Formation (analysis should include major anions, cations, TDS, and conductance of the produced water sample).

4. Record and file static water level with the Well Completion Report (Form 3160-4).

5. Bradenhead (pressure) testing is required for all wells within a 1/2 mile radius of this proposal.

6. Monitor and record cumulative water production.

NOTE: Additional site-specific requirements may be added to the foregoing as necessary.

APPENDIX A-3

APPENDIX A-3

BUREAU OF LAND MANAGEMENT

GENERAL REQUIREMENTS FOR
OIL AND GAS OPERATIONS ON
FEDERAL AND INDIAN LANDS

All lease and/or unit operations will be conducted in such a manner that full compliance is made with applicable laws, regulations (43 CFR 3100), On-Shore Oil and Gas Order No. 1, and the approved plan of operations. The operator is fully responsible for the action of his subcontractors.

1. There shall be no deviation from the approved drilling and/or workover plan. Any changes in the approved plan must have prior approval of this office. Emergency approval may be obtained orally, but such approval does not waive the requirements for filing Sundry Notices (Form 3160-5) in accordance with 43 CFR 3162 and On-Shore Order No. 1.

2. All wells, whether drilling, producing, suspended, or abandoned, must be identified as required by 43 CFR 3162.6.

3. Blow-out prevention (BOP) systems will be consistent with American Petroleum Institute (API) Report 53. Pressure tests will be conducted before drilling out from under all casing strings which are set and cemented in place. Blowout preventer controls will be installed prior to drilling the surface casing plug and will remain in use until the well is completed or abandoned. Preventers will be inspected and operated at least daily to ensure good mechanical working order, and this inspection recorded on the daily drilling report. Preventers will be pressure-tested before drilling casing cement plugs. The Resource Area will be notified two days in advance when pressure tests are to be conducted.

4. If air or gas drilling, the operator shall control the blooie line discharge dust by use of water injection or any other acceptable method. The blooie line discharge shall be a minimum of 125 feet from the BOP and be directed into the blooie pit so that the cuttings and waste are contained in the pit.

5. Approval to flare granted while drilling and testing pursuant to Notice to Leasee (NTL).

6. All fresh water and prospectively valuable minerals encountered during drilling will be recorded by depth, cased, and/or cemented.

7. No location will be constructed or moved, no well will be plugged, and no well will be placed in a suspended status without prior approval of this office. If operations are to be suspended for more than 30 days with no further plans for development, prior approval of this office must be obtained and notification given before resumption of operations.

8. If subsurface cultural resources are unearthed during construction, activity in the area of the resource will cease and the surface managing agency will be notified immediately.

9. All land-altering activity will be confined to the areas surveyed for cultural resources.

10. If the well is to be abandoned, oral approval may be granted by this office but must be timely followed within 30 days with a Sundry Notice, "Request for Approval to Abandon" (Form 3160-5). Unless the plugging is to take place immediately upon receipt of oral approval, this office must be notified at least 48 hours in advance of the plugging, so that a technician may witness plugging operations. Sundry Notice "Subsequent Report of Abandonment" (Form 3160-5) must be filed within 30 days after the actual plugging of the well, reporting actual plugging operations. If a well is suspended or abandoned, all pits must be fenced until they are backfilled.

11. The spud data will be reported orally to this office within 24 hours prior to spudding. If the spudding occurs on a weekend or holiday, notify this office on the last regular work day. For Wildcat wells, periodic drilling progress reports must be filed directly with this office on a weekly basis.

12. Whether the well is completed as a dry hole or as a producer, "Well Completion and Recompletion Report and Log" (Form 3160-4) will be submitted to this office not later than thirty (30) days after completion of the well or after completion of operations being performed, in accordance with 43 CFR 3162.4-1. Two copies of all logs, core descriptions, core analyses, well test data, geologic summaries, sample description, and all other surveys or data obtained and compiled during the drilling, workover, and/or completion operations, will be filed with Form 3160-4. Samples (cuttings, fluids, and/or gases) will be submitted when requested by this office.

13. "Sundry Notice and Report on Wells" (Form 3160-5) will be filed for all changes of plans and other operations in accordance with 43 CFR 3162.4-1. Emergency approval may be obtained verbally, but such approval does not waive the written report requirement. Any additional construction, reconstruction, or alterations of facilities, roads, gathering lines, batteries, measurement facilities, etc., will require the filing of a suitable plan and prior approval by the BLM.

14. Pursuant to 43 CFR 3162.4-1(c), this office must be notified when it is placed in a producing status. Such notification will be by telegram or other written communication and must be received in this office by <u>not later</u> than the 5th business day next following the date on which the well is placed on production. The notification shall provide, as a minimum, the following informational items:

    a. Operator name, address, and telephone number
    b. Well name and number
    c. Well location (1/4, 1/4, Section, Township, Range, and Principal Meridian)
    d. Date well was placed in a producing status or first delivered to pipeline
    e. The nature of the well's production, i.e., crude oil, crude oil and cashinghead gas, natural gas, or natural gas and natural gas liquids
    f. The Federal or Indian lease prefix and number on which the well is located, or the lands category, i.e., State or fee
    g. If appropriate, the unit agreement name and participating area name, or the communication agreement number

15. The reserve pit will be fenced on three sides prior to spudding. The fourth side will be fenced within 24 hours of rig departure.

16. If a completion rig is used for completion operations, all conditions of this approved plan are applicable during all operations conducted with the completion rig.

17. Produced wastewater will be confined to a lined pit for a period not to exceed ninety (90) days after initial production and with a freeboard no less than four (4) feet. During the ninety (90) day period, an application for approval of a permanent disposal method and location, along with the required water analysis, will be submitted to this office for approval pursuant to On-Shore Oil and Gas Order No. 3 (NTL-2B).

18. This application is valid for a period of one year from the date of approval and may be extended by a Sundry Notice request filed prior to expiration. If the application expires, any surface disturbance created under the application must be rehabilitated in accordance with the approved plan, and future operations will require that a new application be filed for approval.

19. Immediate Report: Spills, blowouts, fires, leaks, accidents, or any other unusual occurrences shall be promptly reported to the Resource Area in accordance with requirements of NTL-3A.

20. Notify the Bureau of Land Management office, Durango, at least 24 hours prior to spudding or setting and cementing of casing strings. Address and telephone numbers are:

Bureau of Land Management
Federal Building, Room 203
701 Camino del Rio
Durango, Colorado 81301

Telephone: (303) 247-4082

Contact: _______________, Petroleum Engineering Technician

_______________, Petroleum Engineer

APPENDIX A-4

PINE DISTRICT
SAN JUAN NATIONAL FOREST

STANDARD SURFACE USE PLAN OF OPERATION

I. WELL SIGN

A well sign will be placed on the pad with the following minimum information:

Company Name
Well Name and Number
Legal Location
County, Colorado
Lease Number

II. FIRE PREVENTION

A. A muffler or spark arrester satisfactory to the Forest Service shall be maintained on the exhausts of all trucks and tractors or other internal combustion engines used in conjunction with this operation. An exhaust-driven turbo-charger is considered to be a satisfactory spark arrester.

B. No burning of refuse or clearing debris will be permitted.

C. To the extent practical, the operator will take measures to prevent uncontrolled fires on the area of operation and to suppress uncontrolled fires resulting from operations.

III. CLEARING

A. The cleared area is to be kept to the minimum necessary for drilling operations.

B. All trees cut as a result of clearing for the well pad or access road shall be limbed and tree length skidded to Forest Service-approved landings for later sale by the Forest Service. All trees to be cut will be designated by the Forest Service.

C. All slash created as a result of this operation will be hand-piled in piles 10 feet long, 6 feet wide, and 4 feet high at locations identified by the Forest Service.

D. During clearing and construction operations, should subsurface archaeological materials be exposed, operations will be halted immediately and the District Ranger notified.

IV. CONSTRUCTION

A. Excavation

1. During surveying, clearing, and construction operations, the operator shall protect and preserve all land survey monuments. Records of found corners and monuments shall be given to the Forest Service.

2. Topsoil will be stored to be used later in restoration of the site. Prior to construction of the well site, a topsoil storage area will be approved by the Forest Service.

B. Pit Development

1. Sump pits shall be located so that surface water flows will not enter them. Preferably, they will be located on high ground, but lacking such a location, provision to divert surface flows will be made.

2. Sump and reserve pits will be excavated below natural ground level and the excavated material diked around the edges. The pits shall not be filled to a depth greater than that reached at the natural ground level unless authorized by the Forest Service.

3. Sump and reserve pits will be made impermeable with a liner to prevent leakage.

C. Fence Construction

1. The entire well site will be fenced and a gate or cattleguard provided where the service road crosses the fence. The fence will be built within seven days after initial drilling operations are

completed and will be maintained until the well site is revegetated. Prior to initial drilling operations a temporary fence will be constructed around the reserve pit and will be maintained until the exterior well pad fence is completed.

2. Standard barbed wire fence-wood post construction specifications as shown in attached drawings, pages A-D, will be followed. Any modifications will be approved in advance by the Forest Service Representative.

a. Wood Posts and Poles

(1) Composition. All wood posts and poles shall be peeled and of sound material. They shall be untreated seasoned cedar or pressure-treated pine.

(2) Line Posts. Shall have minimum 3-inch diameter, be 6 feet long, and be planted in the ground a minimum of 2 feet deep and placed 1 rod (16.5 feet) apart. (See page A).

(3) Line Brace, Corner, Gate, and End Posts. Shall have a minimum 6-inch diameter top, be 7 feet long, and be planted in the ground a minimum of 3 feet deep. (See page A).

b. Live Tree Posts. Trees remaining from clearing may be used as live tree posts provided: (1) the trees are 6 inches in diameter at breast height (dbh) or larger; (2) the trees fall within + or - 2 feet of the required rod distance; (3) stretched wire touches or bends around them; and (4) they are protected by slabs of wood nailed to them to which the wires are stapled, and the fence wire does not touch the tree.

c. Stays. Two wooden stays are required, equally spaced between all line posts. Stays must be attached to all fence wires with two wraps of No. 14 gauge tie wire.

d. Line Braces. Line braces are required every 80 rods of fence length or at every major break in topography, whichever comes first.

e. <u>Steel Posts</u>. Commercial steel posts will be necessary where wooden post holes cannot be dug or where solid rock is found within 16 inches of the surface. A rock drill shall be used to drill an 18-inch deep hole for a steel post. The drill shall be small enough to require driving the post into the drilled hole. Steel post may be used only for line posts. When heavy rock is encountered deeper than 16 inches, it shall be drilled with a rock drill or broken by a bar to a 2 foot depth in order to accommodate a wooden post. (See page C).

f. <u>Crossing Draws</u>. The only deviation from standard construction is to make strong well-constructed wire tie-downs which are then tied to heavy rocks to hold the posts in the ground.

g. <u>Barbed Wire</u>. Standard barbed-wire 4-wire fence will have wires 16 inches, 24 inches, 30 inches, and 42 inches above the ground. (See page A of the operating plan.)

h. <u>Line Splices</u>. All line splices will be made using crimped lead splicing sleeves, or the standard construction splice as illustrated on page B of the operating plan.

3. <u>Inspections</u>. Inspections will be conducted while the work is in progress.

D. <u>Access Roads</u>

1. As a condition to the use of National Forest system roads outside of the leasehold, the operator will obtain an approved Road Use Permit. Application forms are available at the Pine District Office.

2. <u>Road Construction/Reconstruction</u> - Forest Development Roads (FDR)

The primary objective of road construction and/or reconstruction is to provide a well-drained maintainable rock-surfaced road (Forest Service Traffic Service Level B) for constant service and reasonable all-weather structural support for oil field truck loads accessing well pads on National Forest lands.

The operator shall provide all engineering services necessary to analyze soil support, and locate and design the road to the indicated alignment design speed in accordance with these design warrants. A Registered Professional Engineer shall perform the needed services and affix his seal to the reports and plans.

The design shall conform to the requirements of the critical vehicle and Transportation Engineering Handbook (FSH 7709.11, Amendment 14, Chapter 20) available for review at the Pine District Office. Construction shall conform to the "U.S. Forest Service Standard Specifications for Construction of Roads and Bridges, 1979 Edition." Copies may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, stock number 001-001-00491-0, at a cost of about $12.00 per copy.

Roadway Design Warrants

a. Location - Flagged location or realignments shall be approved by the Forest Service. The location shall take into account the design speed, good drainage, visual appearance, minimum land impact, slope stability, and other factors.

b. Surveying - Surveys necessary to perform design and construction shall be done. Surveys shall consist of horizontal stationing, profiles, cross-sections, and sufficient information for drainage design. Construction slope stakes shall be provided to assure drainage and compliance with design.

c. Vertical Alignment - Vertical alignment shall be based on 10-mph design constraints and the critical vehicle. New construction maximum sustained grade shall be 6 percent, with pitches not to exceed 10 percent for distances of 300 feet or less. For reconstruction on the existing alignment, the maximum sustained grade will not exceed what currently exists.

d. Horizontal Alignment - Minimum adequate for 10-mph design speed and critical vehicle.

e. Width - Minimum finish top width 12 feet, or greater if necessary to accommodate the critical vehicle. Maximum spacing of turnouts is 1000 feet, preferably closer. Minimum

total width of travelway plus turnout shall be the width of two critical vehicles plus four feet. Turnout length shall be the design vehicle length with minimum 25-foot transition to each end.

f. Clearing Limits - Minimum of five feet beyond the catch point of ditch or toe of fill. Stumps and slash scattered, logs decked.

g. Drainage - Turnpike, with ditches. Permanent drainage (culverts) shall be provided. Rock riprap will be required where erosion will endanger roadway investment. Culverts will be designed for a 10-year flow without a head at the entrance.

h. Slopes - 1 to 1 both cut and fill with 3 to 1 front of ditch.

i. Surfacing - A structural gravel surface shall be provided on the entire length of the project. An acceptable soil strength test, such as the C.B.R. Test, shall be performed to determine gravel depths required for the design maximum truck loads, under 100 percent saturated condition. Gravel thickness will determine the required subgrade width. An acceptable pavement design method shall be used to determine required gravel depths. Six inch minus gravel, grid rolled, may be used as a base. Surfacing shall consist of one inch minus crushed gravel to provide a maintainable top surface minimum compacted depth of 4 inches. All gravel material shall come from a source approved by the U.S. Forest Service. Some areas may require additional surfacing or some widening with surfacing. Subgrade compaction to 95 percent AASHTO T-99 shall be required.

j. Signs. Traffic warning signs shall be placed in accordance with MUTCD.

k. Revegetation - All disturbed areas and segments of roads bypassed will be revegetated in accordance with specifications listed in Section VI., REHABILITATION.

3. Well pad access road on leasehold minimum initial criteria:

a. The access road will be constructed on the flagline location previously approved.

b. Width - Based on the requirement for the design vehicle or 12 feet minimum travelway.

c. Clearing Limits - Two feet beyond shoulder of the road or that require for passage of the design vehicle.

d. Drainage - Ditches in turnpike sections, sidehill sections shall have a ditch on cut side with ditches on both sides in through cuts. Drainage crossings shall be rock armored waterbars, rock armored waterdips or culvert metal pipes. Rock riprap will be required in areas of erosion hazard.

e. Slopes - 1 to 1 both cut and fill, 3 to 1 front ditch slope.

f. Surfacing - Natural/earth surfacing or rock as required for reasonable access.

g. Cleanup - Stumps and slash shall be scattered. Slash shall be cut to lie within one foot of the ground surface. Drainages shall not be blocked by slash.

h. Revegetation - All disturbed areas will be revegetated in accordance with specification listed in Section VI. REHABILITATION.

V. OPERATIONS

The operator will notify the District Ranger of the various phases of the overall operations including but not limited to completion of the well, rework of the well, a change in the method of operations of the well, etc.

All operations will be conducted during the period May 1 to November 30. Operations outside of this period will be evaluated upon written request to the District Ranger for such considerations. Approval or disapproval will be given in writing.

A. Drilling Operations

1. It is herein agreed that during all operations, the operator shall maintain his structures, equipment and other facilities in a safe, neat and workman like manner. Hazardous sites or conditions resulting from the operations shall be marked by signs, fenced or otherwise identified to protect the public.

2. In the event of a pit leak or spill, the Forest Service shall immediately be notified. Cleanup operations from the leaking pit shall be reviewed by the Forest Service representative and recommend additional action as necessary.

3. Certification or other approval issued by State Agencies or compliance with and regulations relating to drilling operations above and beyond the requirements of these stipulations will be accepted.

4. The vehicle traffic gate at the Forest boundary will be kept closed at all times except for vehicle passage. At any time the well pad is unoccupied by company personnel, the gate will be locked.

B. Water Sources

No water will be removed from or disposed of on National Forest lands, stockponds, or spring developments without prior written approval from the Forest Service.

C. Road Maintenance

1. The operator shall maintain all Forest Service-owned or -controlled roads used in conjunction with operations as herein outlined:

   a. Remove slides, boulders, fallen timber, overhanging brush, and other material obstructing safe road sight distance.

   b. Replace fills and portions of fills lost and/or which have settled below the original grade and cross-section.

c. Keep drainage channels, ditches, and culverts clear of debris and functioning as intended.

d. Repair fences, cattleguards, culverts, bridges, and other road structures.

e. Blade and shape surface and shoulders to maintain the original cross-section and provide a suitable riding surface. Earth and debris from side ditches, slides, or other sources shall not be left on the road or mixed into the surface portions of the road. Blading must not undercut banks, nor shall gravel or other selected surface material be bladed off the surface width. Material from slides or other sources requiring removal from the road shall not be deposited in streams or stream channels or at locations where it will wash into streams and cause damage through silting or obstructing of streams or reservoirs.

f. To facilitate operations, the operator may remove snow from existing National Forest roads. Such removal shall be done in a manner to preserve and protect roads during operations to the extent necessary to ensure safe and efficient transportation and to prevent excessive erosion damage to roads, streams, and other Forest values.

Snow removal work shall include: (1) removal of snow from all or part of the traveled way, including sufficient turnouts for safe and efficient use, and (2) leaving culvert inlets in a natural condition without snow plowed into them so that the drainage system will function normally.

The operator shall perform snow removal work as follows:

(1) All debris, except snow and ice, that is removed from the road surface and ditches shall be deposited away from stream channels at agreed-upon locations.

(2) Banks shall not be undercut, nor shall gravel or other surfacing materials be bladed off the road.

(3) Ditches and culverts shall be kept functioning during operations and upon completion of operations.

(4) "Snow Berm" is herein defined as a dike of snow resulting from operator's snow removal operations which extends above the surface of the traveled way.

Operator shall space, construct, and maintain drainage holes in snow berms as necessary to obtain surface drainage without discharge on erodible fills. In any event, operator shall remove snow berms or construct drainage holes at the end of winter operations or before the spring breakup, whichever is sooner.

(5) With written approval of Forest Service, dozers may be used to plow snow on roads.

(6) Equipment used to plow snow shall be equipped with shoes or runners to keep the blade a minimum of two inches above the road surface, unless otherwise agreed in writing.

Forest Service shall notify the operator in writing if surfacing material has been bladed off the road. The notice shall state the number of road miles (rounded up to the next 0.1 mile) and the cubic yard equivalent of surfacing bladed off. The Forest Service calculation of the cubic yards will be available for review. Upon such notice, the operator shall replace the surfacing material in kind no later than 90 days after notification, unless otherwise agreed in writing.

g. All maintenance shall be performed as needed. In addition, at the end of each operating season, maintenance work will be done to minimize damage from adverse weather. Such work shall include final blading to remove ruts and other irregularities that would prevent normal road surface runoff, and final clearing of drainage ditches and culverts to ensure satisfactory functioning of the road drainage system.

D. <u>Sanitation and Garbage</u>

1. A portable toilet will be made available. Sewage will be contained and disposed of at a designated sanitary disposal facility.

2. The well pad and adjoining areas will be kept in a neat and sanitary condition during all phases of the operation.

3. No oil will be drained on the ground.

4. The well pad, adjoining area, and road will be thoroughly cleaned of all trash and discarded equipment within 5 days of termination of operations. Cleanup operations also include removing all flagging, wooden lath, signs and other identifying devices from National Forest System lands.

5. The operator shall dispose of refuse from this use, including waste materials, garbage, and rubbish of all kinds, by removing it from National Forest System lands.

E. Representatives

The representative for the Forest Service will be designated by the Pine District Ranger.

VI. REHABILITATION

A. If the well does not prove to be a producer, the entire access road and well site shall be rehabilitated.

1. Pits

a. After completion of drilling operations, drilling fluids will be disposed of within 30 days upon cessation of drilling operations and/or completion operations.

b. Drill cutting and mud solids will be placed in the reserve pit and buried upon completion of operations.

c. Excavated material used to dike the pits will be used for fill.

d. The well site will be contoured to similar preconstruction conditions.

e. Stored topsoil will be respread over the entire well site.

2. Access Roads (Non-FDR System)

a. Fill material at drainage crossings will be excavated to original contour.

b. The road surface will be outsloped 3 percent for its entire length.

3. Site Preparation

All soil areas disturbed as a result of operations will be scarified to at least a 4-inch depth and drainage structures installed at Forest Service-specified locations.

4. Revegetation

a. After scarifying the access road and well pad it will be revegetated with the following seed mixture or equivalent of pure live seed:

Smooth Brome grass-Manchar variety	8 lbs/ac
Crested wheat grass-Nordan variety	4 lbs/ac
Intermediate wheat grass-Oahe variety	4 lbs/ac
Pubescent wheatgrass-Luna variety	4 lbs/ac
	20 lbs/ac

For turkey habitat enhancement, use the following seedmix:

Smooth Brome grass-Manchar variety	4 lbs/ac
Western wheat grass-Arriba variety	6 lbs/ac
Intermediate wheat grass-Oahe variety	7 lbs/ac
Mangor Basin wild rye	3 lbs/ac
	20 lbs/ac

It is recommended that either seed mixture be applied with a drill.

b. Seeding or planting will be done at a time of year that the District Ranger considers offers the best chance of success, and will be repeated until such areas are accepted in writing by the District Ranger as satisfactorily revegetated and stabilized.

c. The operator is responsible for treating and eliminating any noxious weeds that may be introduced and established on disturbed areas resulting from this activity. This responsibility remains in effect until the disturbed areas are revegetated and accepted.

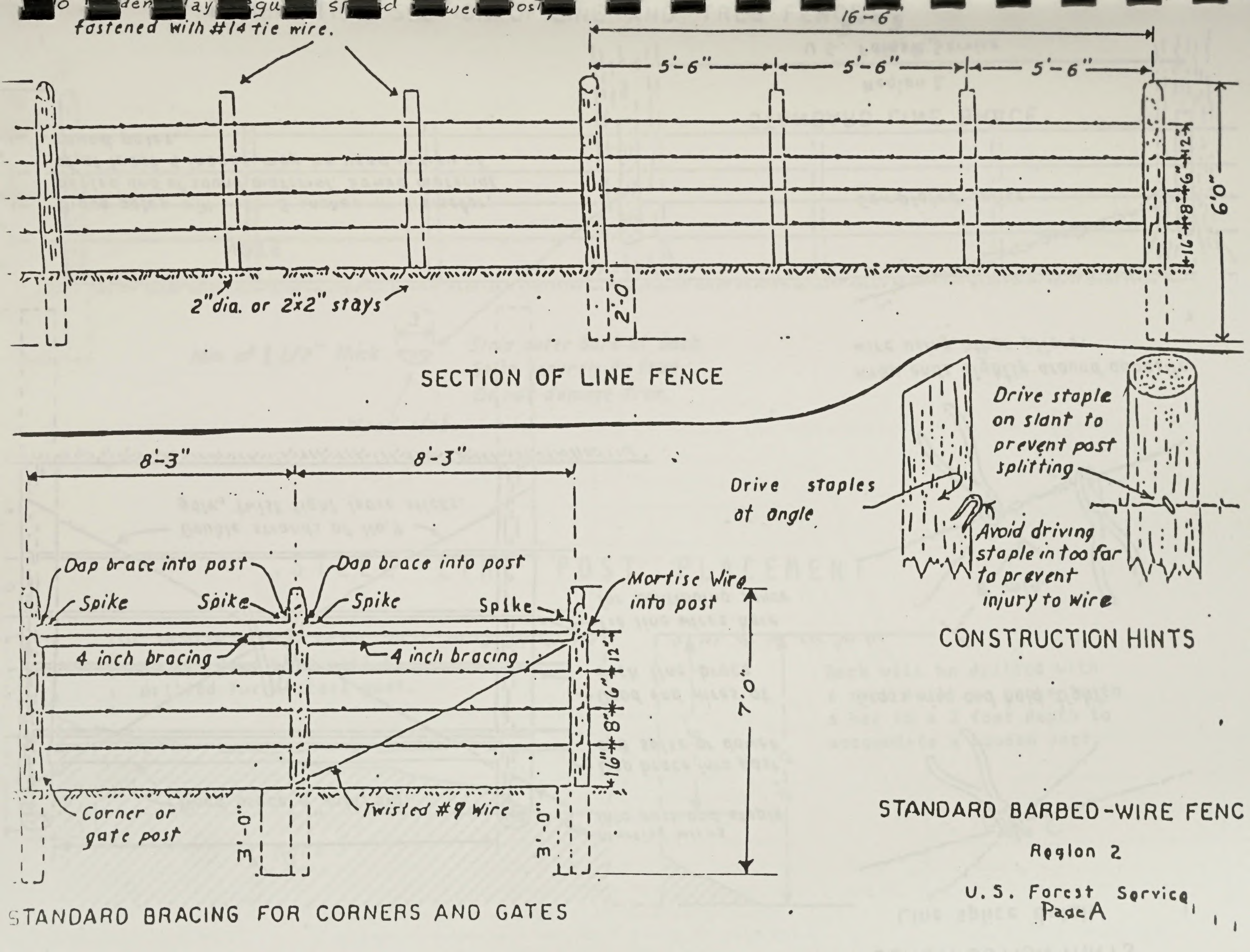
B. If the well proves to be a producer, those portions of the well pad not necessary for operations shall be rehabilitated as specified previously and will include the following:

1. All permanent structures and equipment will be painted with one of the Standard Environmental Colors recommended by the Rocky Mountain Five State Interagency Committee and approved by the Forest Service.

2. Additional requirements may be necessary for surface resource protections and reclamation.

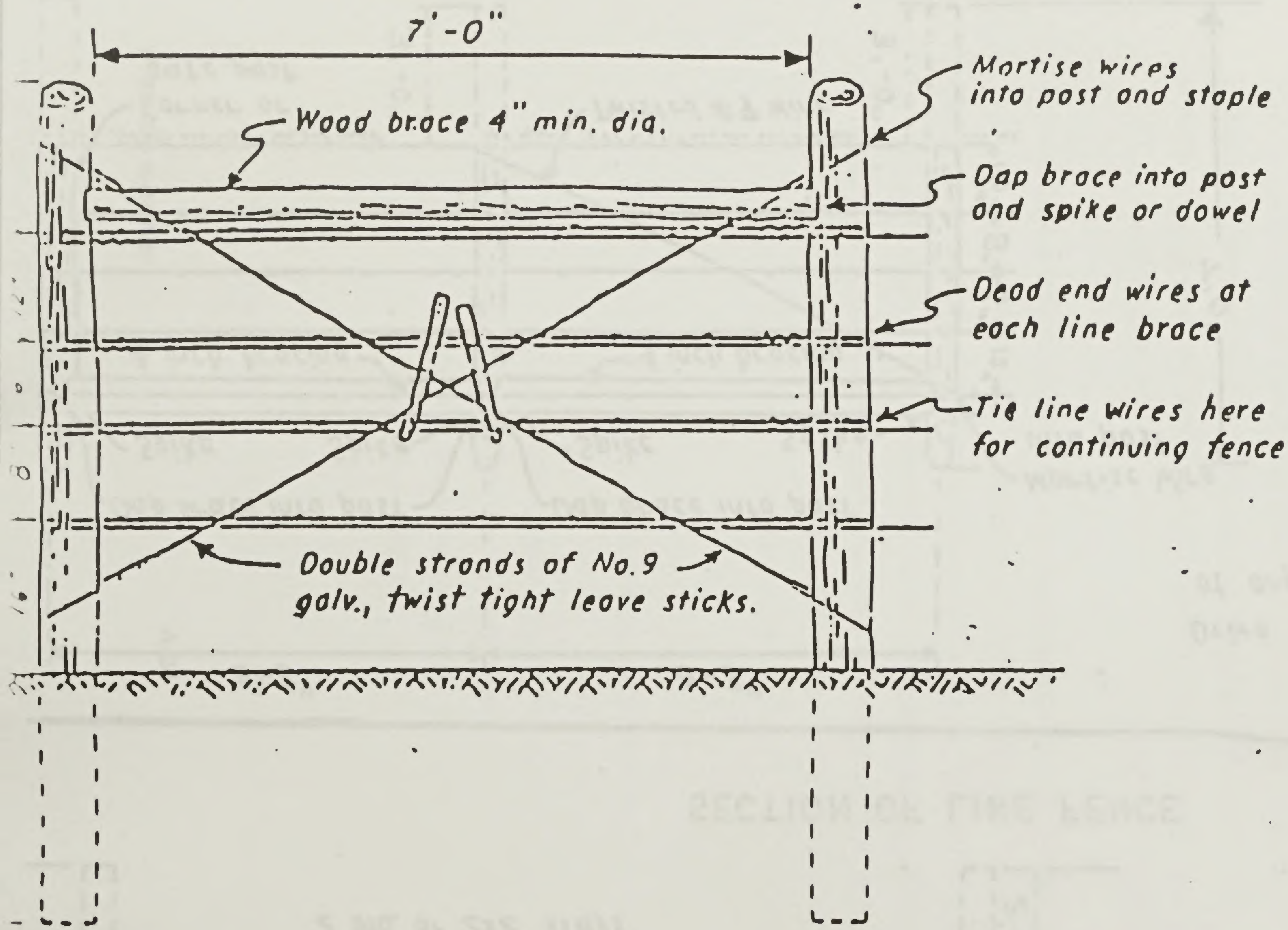
C. Monitoring - All facets of the surface operation will be monitored by the Authorized Forest Service Officer or his representative to assure compliance to the Surface Use Plan of Operations. This will begin upon receiving notice that operators will commence operation and will continue throughout the active phases of well development on a regular visitation process and will continue on a periodic visitation until abandoned.

FENCE DRAWINGS



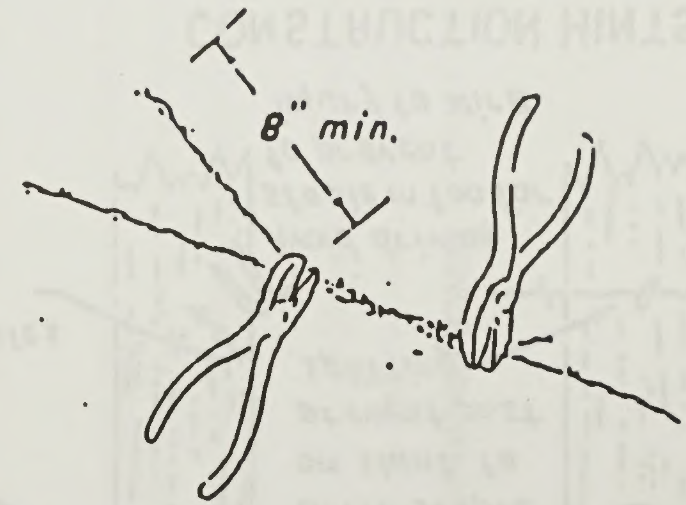
fastened with #14 tie wire.
16'-6"
5'-6"
5'-6"
5'-6"
6'0"
16"
8"
6"
12"
2'-0"
2" dia. or 2"x2" stays
SECTION OF LINE FENCE
Drive staple on slant to prevent post splitting
Drive staples at angle
Avoid driving staple in too far to prevent injury to wire
CONSTRUCTION HINTS
8'-3"
8'-3"
Dap brace into post
Dap brace into post
Spike
Spike
Spike
Spike
Mortise Wire into post
4 inch bracing
4 inch bracing
7'0"
12"
6"
8"
16"
Corner or gate post
3'-0"
3'-0"
Twisted #9 Wire
STANDARD BRACING FOR CORNERS AND GATES
STANDARD BARBED-WIRE FENC
Region 2
U.S. Forest Service
Page A

CONSTRUCTION HINTS

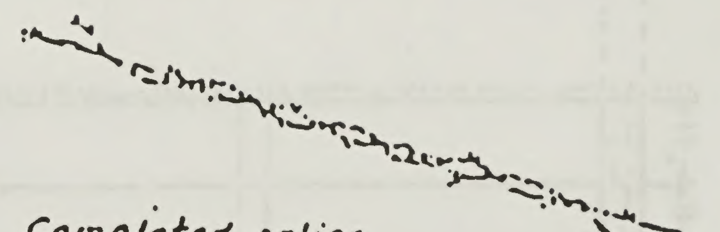


Line splice detail

Cross wire and hold tight.



Wrap ends tightly around opposite wire using other pliers.



Completed splice

NOTE

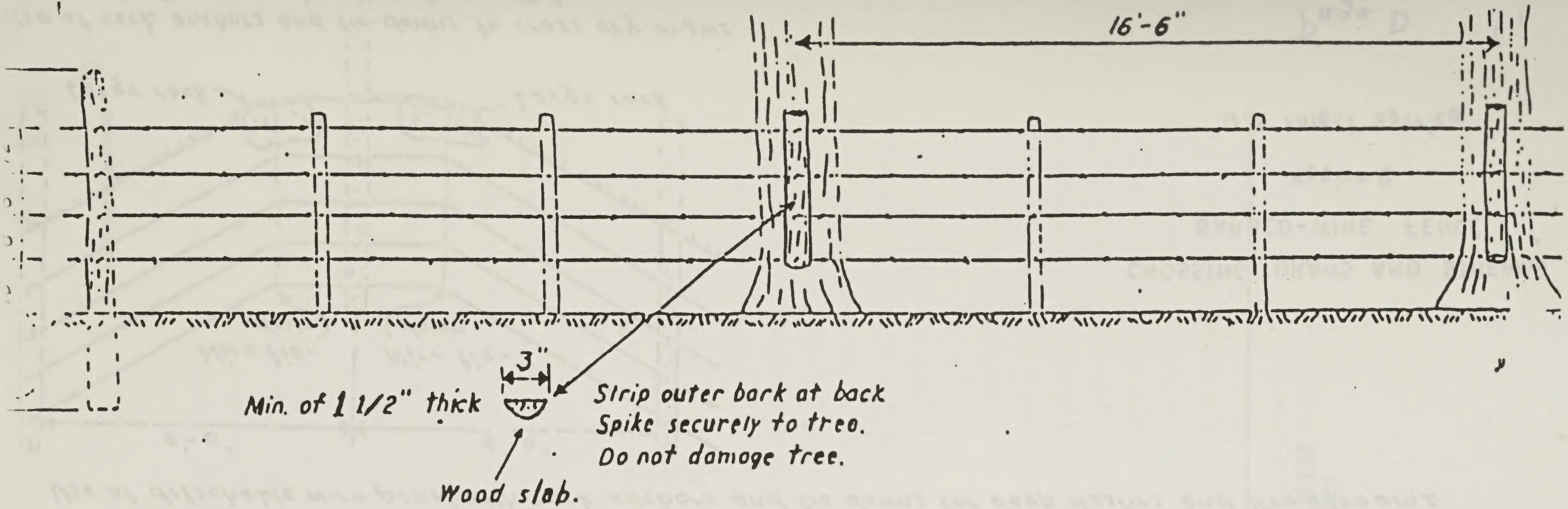
Brace poles will be 5 inches in diameter, peeled and of sound material. Sawed material of at least 4 inches may be used in lieu of round poles.

STANDARD LINE BRACE

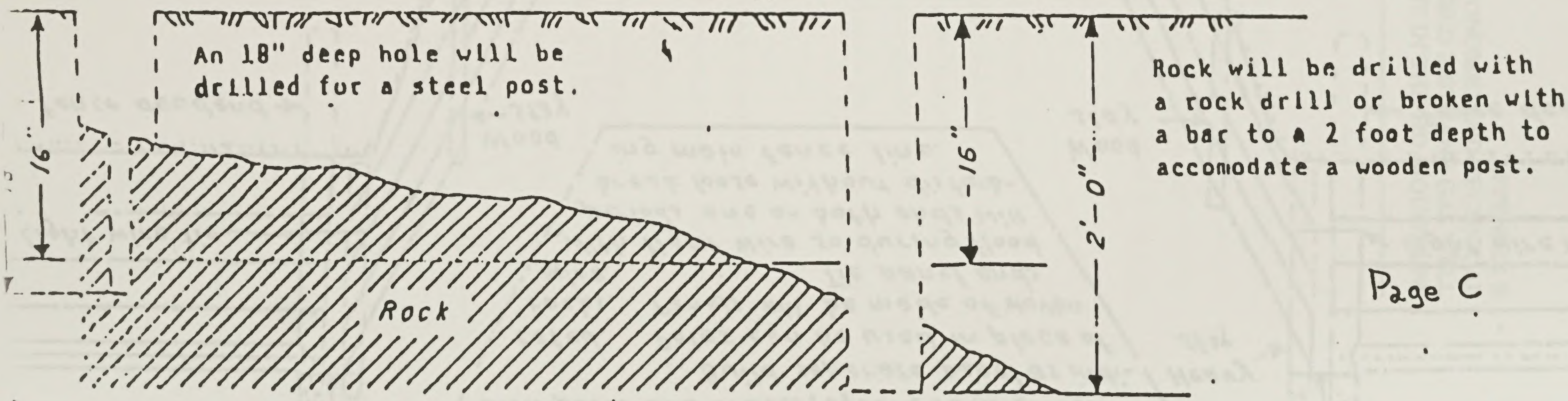
Region 2

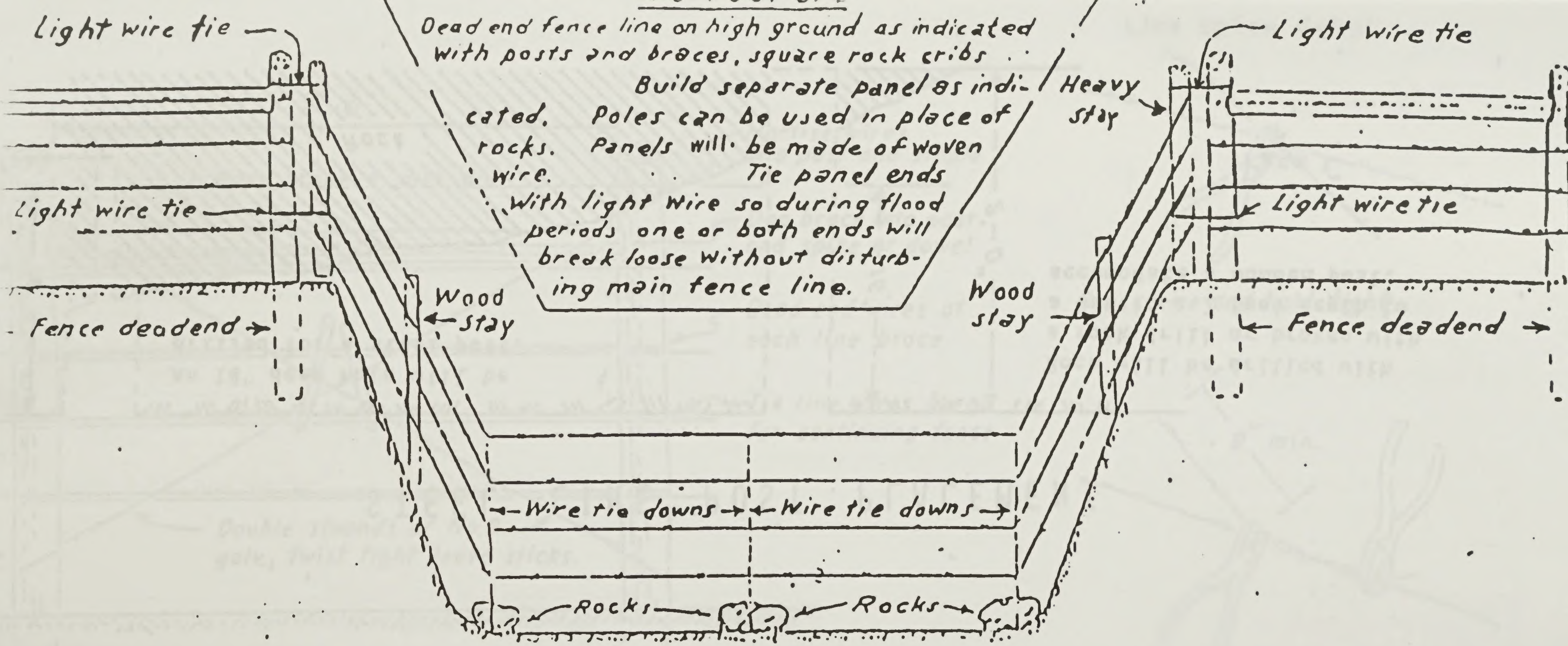
U S. Forest Service

SECTION OF LINE AND TREE FENCE

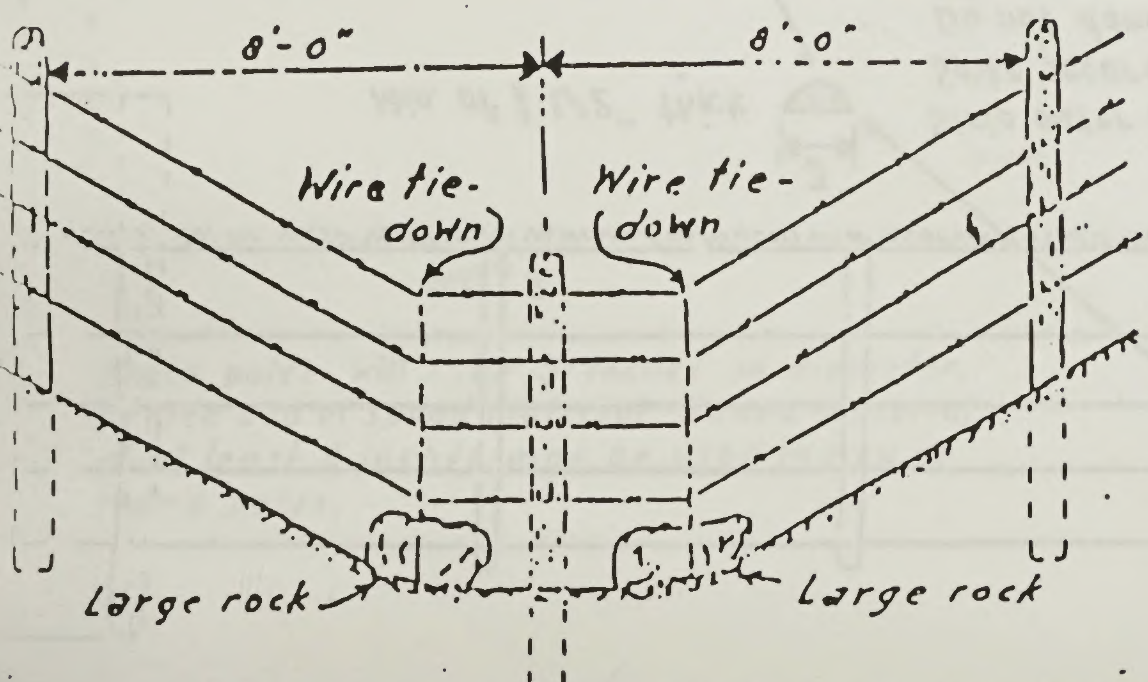


STEEL LINE POST PLACEMENT





Use of detachable wire panel with rock anchors and tie downs for deep washes and live streams.



Use of rock anchors and tie-downs to cross dry draws

CROSSING DRAWS AND STREAMS

BARBED-WIRE FENCE

Region 2

U.S Forest Service

APPENDIX B
EXPLANATION OF THE ECONOMIC AND TECHNICAL EXCLUSION AREA FOR COALBED METHANE GAS WELL DEVELOPMENT IN THE HD MOUNTAINS

APPENDIX B

PERMEABILITY REDUCTION WITH DEPTH
AMOCO PRODUCTION COMPANY

In the Forest Service area covered by the EIS, some areas have been excluded from current and future development based on depth of the coalbed methane formation. Performance from existing wells and limited permeability testing have indicated that coals deeper than 4,000 feet (depth to the coal formation) do not have the flow capacity needed for economic development (Amoco files 1989). The coals contain representative quantities of gas-in-place, as tested from coal samples, but do not have sufficient permeability needed for gas production in economic quantities (Amoco files 1989). Permeability is critical in allowing gas to move through the coal formation.

A contour map has been developed which shows the 4,000 feet depth to the coal bed formation on Forest Service lands (Amoco files 1989). The Fruitland coals in this area have a gentle 1 to 2 degree regional slope, but have an extra 1,000 to 2,000 feet of sediments overlying the production coal bed interval. This extra overburden consists of Tertiary sediments which have not eroded in this area as they have in other parts of the basin. The extra overburden has theoretically closed the natural cleat in the coal and reduced permeability of flow capacity.

This conclusion has been proven with previous wells drilled in the HD Mountains. In fact, Amoco has tested two wells below 4,000 feet in this area. Both of these wells had very low, uneconomic production rates even after extensive testing (Amoco files 1989). One of these wells, the Pargin Mountain Unit No. 2 well, had a gas content very similar to wells in the Bayfield and Ignacio areas. However, during routine well cleaning-out for eventual production of Pargin Mountain Unit No. 2, gas flow ceased and the well was eventually recompleted to the underlying Mesa Verde formation as a conventional well. In contrast, wells to the east along the Piedra River drainage and only 3,100 feet deep had very economical flow rates, and the area is now scheduled for further development. Amoco has used performance from these wells and additional industry data sources to conclude that development potential is limited below 4,000 feet in this area.

Outside of Amoco, there is a considerable amount of industry data which supports these conclusions: (1) Frontiers, Petroleum Information's publication on coal degas reported that for several basins, including San Juan, there was a strong correlation of decreasing permeability with depth. Shallow coals tend to have higher permeability than deeper coals. (2) Fracture-dominated reservoirs and cleated coals considered

fractured are known to exhibit this characteristic stress-dependent behavior; the idea of stress-dependent permeability has been investigated by Gas Research Institute and others; the results for coals in Colorado are presented in Harpanlani and McPherson (1985). (3) Changing permeability with depth or pressure has been reported in the literature on coals, and (4) the literature clearly supports the overburden concept.

All this literature and performance in the area indicates that there is a depth or overburden limit to economic production. This limit appears to be at 4,000 ft in the HD Mountains area, and acreage with Fruitland coals below this depth have been excluded from future development under current technology. This is not to say that, given technological advances and price incentives, future development could be ruled out, but development in the foreseeable future is very unlikely.

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Harpelani, S., McPherson, M.J. Effects of stress on permeability of coal. Gas Research Institute Quarterly Review of Methane from Coal Seams Technology. 1985. Vol. 3. No. 2. p. 23-28.

Petroleum Information Corp. Petroleum Frontiers. Coalbed Methane. Vol. 3. No. 4. 1986. p. 20.

Pomeroy, C.D., and D.J. Robinson. The effect of applied stresses on the permeability of a middle rank coal to water. Int. J. Rock Mech. Min Sci. 1967. 4:329-349.

Somerton, W.H., et al. Effects of stress on permeability of coal. U.S. Bureau of Mines Open File Rpt. OFR-45-74.

APPENDIX C-1
CHARACTERIZATION OF SOIL MATERIALS FOR THE STABILIZATION AND REVEGETATION OF DRASTICALLY DISTURBED AREAS

APPENDIX C-1

CHARACTERIZATION OF SOIL MATERIALS FOR THE STABILIZATION AND REVEGETATION OF DRASTICALLY DISTURBED AREAS

Soil Property	Limits			Restrictive Feature
	Good	Fair	Poor	
Sodium Adsorption Ratio	<5	5-12	>12	Excess Sodium
Salinity (MMHOS/CM)[1]	<8	8-16	>16	Excess Salt
Toxic Materials	Low	Medium	High	Toxicity
Soil Reaction (pH) (0-40")	5.6-7.8	4.5-5.5	<4.5	Too Acid
Available Water Capacity (In/In)[2]	>.10	.05-.10	<.05	Droughty
Erodibility Factor (K)	<.35	>.35	--	Erodes Easily
Wind Erodibility Group	--	--	1, 2	Soil Blowing
USDA Texture	--	Sandy clay loam, clay loam, silty clay loam	Clay, silty clay, sandy clay	Too Sandy
USDA Texture		Loamy coarse sand, loamy fine sand, loamy very fine sand	Coarse sand, sand, fine sand, very fine sand	Too Sandy
Coarse Frag. (Wt. PCT)[3]				
3-10 in.	<15	15-35	>35	Large Stones
>10 in.	<3	3-10	>10	Large Stones

[1] Millimhos per centimeter
[2] Inches of water per inch of soil
[3] Weight percentage

Source: SCS (1983)

APPENDIX C-2
SOIL LIMITATIONS FOR REVEGETATION

APPENDIX C-2

SOIL LIMITATIONS FOR REVEGETATION

Parameters	Degree of Limitations		
	Slight	Moderate	Severe
1. Inherent Fertility	High	Moderate	Low
2. Onsite Erosion	Low	Moderate	High
3. Shrink-Swell Potential[1]	Low	Moderate	High
4. Coarse Fragments[2]	<20	20-50	>50
5. pH Range (grass)	6.6-7.8	(5.1-6.5) or (7.9-8.4)	(<5.1) or (>8.4)
6. pH Range (shrubs)	6.1-7.8	(5.5-6.0) or (7.9-8.4)	(<5.1) or (>8.4)
7. Slope (%)	<30 (<3:1) (<13.5°)	30-60 (3:1 to 1 1/2:1) (13.5° to 27.0°)	<60 >1 1/2:1) (>27.0°)

1 Moderate to high-rated soils shrink on drying: this shrinkage may expose or sever the plant roots.

2 Refers to surface and subsurface rock fragments of the following size ranges:

Gravel is 2mm to 3" in diameter
Cobble is 3" to 10" in diameter
Stones are 10" to 24" in diameter
Boulders are >24" in diameter

Source: Forest Service Handbook (2509.18)

APPENDIX C-3
CRITERIA FOR SEPARATING SLOPE UNITS

APPENDIX C-3

CRITERIA FOR SEPARATING SLOPE UNITS

0-6 percent	1)	Facilities can easily be constructed on these slopes without having a major impact (U.S. Department of Interior, Bureau of Land Management (BLM 1981).
	2)	The 6 percent slope falls within and provides a conservative estimate of a maximum slope for road gradients of 8 percent recommended by the USFS and the BLM (BLM and FS 1989).
6-15 percent	1)	15 percent is a maximum grade which can be climbed by standard oil and gas vehicles for short stretches (R.A. Bell, personal communication, 1990).
15-25 percent	1)	25 percent is the maximum gradient above which (a) roads constructed perpendicular to the slope would result in either excessive disturbance or possible erodible side slopes and (b) most soils will erode and rehabilitation of vegetation and topography is difficult (BLM 1981).
25-40 percent	1)	Slopes in excess of 40 percent can have limiting factors including stability problems, high erosion, and difficult revegetation and construction (BLM and FS 1989).
40-60 percent	1)	Slopes in excess of 60 percent pose severe limitations to revegetation (Appendix C-2).

Note: Map displaying the above slope units is in the project file.

APPENDIX C-4
PROCEDURE FOR ESTABLISHING EROSION POTENTIALS FOR AREAS WITHIN THE STUDY AREA USING THE SLOPE MAP AND K FACTORS FOR THE SOIL MAP UNITS

APPENDIX C-4

PROCEDURE FOR ESTABLISHING EROSION POTENTIALS FOR AREAS WITHIN THE STUDY AREA USING THE SLOPE MAP AND K-FACTORS FOR THE SOIL MAP UNITS

The equation and critical values defining the classification of impact due to water erosion are:

Slope x K factor = Erosion value

Erosion value	=	Low potential when <4
	=	Moderate potential when 4-8
	=	High potential when >8

Source: Nevada SCS Form 5 Guide 1983

APPENDIX C-5

STREAM CLASSIFICATIONS AND NUMERIC WATER QUALITY STANDARDS FOR SELECTED WATERBODIES WITHIN THE STUDY AREA

STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 9 Page 5

BASIN: LOS PINOS RIVER

Stream Segment Description	DESIG: HI QUAL 1	DESIG: HI QUAL 2	DESIG: USE PROT	CLASSIFICATIONS: REC CL 1	REC CL 2	AQUATIC LIFE CL1 C	AQUATIC LIFE CL1 W	AQUATIC LIFE CL2 C	AQUATIC LIFE CL2 W	WATER SUP	AGRICULT	NUMERIC STANDARDS: PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS mg/l			TEMPORARY MODIFICATIONS and QUALIFIERS
1. All tributaries to the Los Pinos River, including all lakes and reservoirs, which are within the Weminuche Wilderness Area.		X		X		X				X	X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002 B=0.75	NO_2=0.05 NO_3=10.0 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1,000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1,000(Trec) Hg(ch)=.01(Trec)	Ni(ac/ch)=TVS Se(ac)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS(tr) Zn(ch)=TVS	
2a. Mainstem of the Los Pinos River from the boundary of the Weminuche Wilderness Area to U.S. Hwy 160 except for the specific listing in Segment 3.		X		X		X				X	X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002 B=0.75	NO_2=0.05 NO_3=10.0 Cl=250.0 SO_4=250.0	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1,000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1,000(Trec) Hg(ch)=.01(Trec)	Ni(ac/ch)=TVS Se(ac)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS(tr) Zn(ch)=TVS	
2b. Mainstem of the Los Pinos River from U.S. Hwy 160 to the Colorado/New Mexico border.		X		X		X				X	X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002 B=0.75	NO_2=0.05 NO_3=10.0 Cl=250.0 SO_4=250.0	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1,000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1,000(Trec) Hg(ch)=.01(Trec)	Ni(ac/ch)=TVS Se(ac)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS(tr) Zn(ch)=TVS	
3. Vallecito Reservoir.		X		X		X				X	X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002 B=0.75	NO_2=0.05 NO_3=10.0 Cl=250.0 SO_4=250.0	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1,000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1,000(Trec) Hg(ch)=.01(Trec)	Ni(ac/ch)=TVS Se(ac)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS(tr) Zn(ch)=TVS	
4. All tributaries to the Los Pinos River and Vallecito Reservoir, including all lakes and reservoirs, from the boundary of the Weminuche Wilderness Area to a point immediately below the confluence with Bear Creek (T35N, R7W), except for the specific listing in Segment 5; mainstems of Beaver Creek, Ute Cr Creek, Ute Creek, and Spring Creek from their sources to their confluences with the Los Pinos River				X		X				X	X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002 B=0.75	NO_2=0.05 NO_3=10.0 Cl=250.0 SO_4=250.0	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1,000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1,000(Trec) Hg(ch)=.01(Trec)	Ni(ac/ch)=TVS Se(ac)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS(tr) Zn(ch)=TVS	

STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 9 Page 3

BASIN: PIEDRA RIVER

Stream Segment Description	DESIG HI QUAL 1	DESIG HI QUAL 2	DESIG USE PROT	REC CL 1	REC CL 2	AQUATIC LIFE CL1 C	AQUATIC LIFE CL1 W	AQUATIC LIFE CL2 C	AQUATIC LIFE CL2 W	WATER SUPP	AGRICULT	PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS mg/l			TEMPORARY MODIFICATIONS and QUALIFIERS
1. All tributaries to the Piedra River, including all lakes and reservoirs, which are within the Weminuche Wilderness Area.		X		X		X				X	X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002 B=0.75	NO_2=0.05 NO_3=10.0 Cl=250.0 SO_4=250.0	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1,000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1,000(Trec) Hg(ch)=.01(Trec)	Ni(ac/ch)=TVS Se(ac)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS(tr) Zn(ch)=TVS	
2. Mainstem of the Piedra River, including the East and Middle Forks, from the boundary of the Weminuche Wilderness Area to the conclence with Indian Creek, except for the specific listing in Segment 3.		X		X		X				X	X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002 B=0.75	NO_2=0.05 NO_3=10.0 Cl=250.0 SO_4=250.0	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1,000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1,000(Trec) Hg(ch)=.01(Trec)	Ni(ac/ch)=TVS Se(ac)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS(tr) Zn(ch)=TVS	
3. Mainstem of the East Fork of the Piedra River from the Piedra Falls Ditch to the confluence with Pagosa Creek.		X		X		X				X	X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002 B=0.75	NO_2=0.05 NO_3=10.0 Cl=250.0 SO_4=250.0	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1,000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1,000(Trec) Hg(ch)=.01(Trec)	Ni(ac/ch)=TVS Se(ac)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS(tr) Zn(ch)=TVS	
4. Mainstem of the Piedra River from the confluence with Indian Creek to Navajo Reservoir.				X		X					X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002	B=0.75 NO_2=0.05 NO_3=100.0	As(ch)=50 Cd(ch)=.4 CrIII(ch)=100 CrVI(ch)=25 Cu(ch)=16	Fe(ch)=1,500 Pb(ch)=4 Mn(ch)=1,000 Hg(ch)=.05 Ni(ch)=50	Se(ch)=20 Ag(ch)=.1 Zn(ch)=50	All metals are Trec unless otherwise noted
5. All tributaries to the Piedra River, including all lakes and reservoirs, from the boundary of the Weminuche Wilderness Area to a point immediately below the confluence with Devil Creek.		X		X		X				X	X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002 B=0.75	NO_2=0.05 NO_3=10.0 Cl=250.0 SO_4=250.0	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1,000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1,000(Trec) Hg(ch)=.01(Trec)	Ni(ac/ch)=TVS Se(ac)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS(tr) Zn(ch)=TVS	
6. All tributaries to the Piedra River, including all lakes and reservoirs, from a point immediately below the confluence with Devil Creek to Navajo Reservoir, except for the specific listings in Segment 7.			X		X					X	X	D.O. = 5.0 mg/l pH = 6.5-9.0 F.Coli=2000/100ml						

STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 9 Page 2 BASIN: San Juan River	DESIG HI QUAL 1	DESIG HI QUAL 2	DESIG USE PROT	CLASSIFICATIONS REC 1	REC 2	AQUATIC LIFE CL1 C	CL1 W	CL2 C	CL2 W	WATER SUPPLY	AGRICULT	NUMERIC STANDARDS PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			TEMPORARY MODIFICATIONS and QUALIFIERS
Stream Segment Description	1	2		1	2	C	W	C	W									
6. Mainstem of the San Juan River from the coflnence with Fourmile Creek to Navajo Reservoir.				X		X					X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002	B=0.75 NO_2=0.05 NO_3=100.0	As(ch)=50 Cd(ch)=.4 CrIII(ch)=100 CrVI(ch)=25 Cu(ch)=20	Fe(ch)=2,400 Pb(ch)=10 Mn(ch)=1,000 Hg(ch)=50 Ni(ch)=50	Se(ch)=20 Ag(ch)=.1 Zn(ch)=50	All metals are Trec unless otherwise noted
7. Navajo Reservoir (portion in Colorado).				X			X			X	X	D.O. = 5.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002 B=0.75	NO_2=0.5 NO_3=10.0 Cl=250.0 SO_4=250.0	As(ch)=50 Cd(ch)=.4 CrIII(ch)=50 CrVI(ch)=25 Cu(ch)=5	Fe(ch)=300(dis) Fe(ch)=1,000 Pb(ch)=4 Mn(ch)=50(dis) Mn(ch)=1,000	Hg(ch)=.05 Ni(ch)=50 Se(ch)=10 Ag(ch)=.1 Zn(ch)=50	All metals are Trec unless otherwise noted
9. Mainstem of the Rio Blanco, including all tributaries, lakes, and reservoirs, from the boundary of South San Juan Wilderness Area to the coflnence with the San Juan River, except for the specific listing in Segment 10.		X		X		X				X	X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ch)=0.02 CL_2=0.003 CN=.005 S=0.002 B=0.75	NO_2=0.05 NO_3=10.0 Cl=250.0 SO_4=250.0	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1,000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1,000(Trec) Hg(ch)=.01(Trec)	Ni(ac/ch)=TVS Se(ac)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS(tr) Zn(ch)=TVS	
10. Mainstem of the Rito Blanco River from Echo Ditch to the cosflnence with the RioBlanco River.			X		X			X			X	D.O. = 6.0 mg/l D.O.(sp)= 7.0 mg/l pH = 6.5-9.0 F.Coli=2000/100ml						
11. All tributaries to the San Juan River in Archuleta County, including all lakes and reservoirs, except for specific listings in Segments 1, 4, 5, and 9.			X		X				X		X	D.O. = 5.0 mg/l pH = 6.5-9.0 F.Coli=2000/100ml						

Source: Colorado Water Quality Control Commission 1990

APPENDIX C-6
WRIS ELK SEASONAL ACTIVITY AREAS

APPENDIX C-6

WRIS ELK SEASONAL ACTIVITY AREAS

DEFINITIONS

Winter Range

That part of the home range of a species where 90 percent of the individuals are located during a site-specific period of winter during the average five winters out of ten (this period is defined by CDOW personnel for each Data Analysis Unit {DAU}).

Winter Concentration Areas

That part of the winter range of a species where densities are X percent greater than the surrounding winter range density during the same period used to define winter range in the average five winters out of ten. Densities are defined for each DAU by CDOW personnel.

Severe Winter Range

That part of the range of a species where 90 percent of the individuals are located when the annual snowpack is at its maximum in the two worst winters out of ten.

Highway Crossings

An area within the home range of a species defined by more than six highway mortalities per mile of highway or railroad per year.

Migration Corridors

A specific mappable site through which large numbers of animals migrate and loss of which would change migration routes.

Migration Pattern

A subjective indication of the general direction of the fall movements of a migratory ungulate herd.

Production Areas

That part of the home range of a species occupied by the females during a specific period of spring. This period is May 15 to June 15 for elk (only known areas are mapped and this does not include all production areas for the DAU).

Resident Population Areas

Areas with distinct populations of a species that fulfill all biological functions within the area identified. Individuals could be found in any part of the area at any time of the year.

Summer Range

That part of the home range of a species that is not considered winter range, including what has traditionally been known as spring and fall transitional ranges.

Critical Habitat

A designation which may be applied to any activity area mapped for a species, thus indicating that with a given DAU, loss of that activity area would adversely affect that species. Mapping any activity area does not arbitrarily classify that feature as "critical."

Disclaimer

Care should be taken in interpreting these maps. The activity areas portrayed here are graphic representations of phenomena that are difficult to reduce to two dimensions. Animal distribution is fluid, animal populations are dynamic, and either may vary considerably from what is shown here. Tabular and narrative information accompanies these maps and should be considered.

APPENDIX C-7
VISUAL RESOURCES

APPENDIX C-7

VISUAL RESOURCES

VISUAL QUALITY OBJECTIVE CLASSIFICATIONS

PRESERVATION (P)

This Visual Quality Objective (VQO) allows ecological changes only. Proposed activities, except for very low visual impact recreation facilities, are prohibited. This objective applies to wilderness areas, primitive areas, other special classified areas, areas awaiting classification, and some unique forest management units which justify special classification.

RETENTION (R)

This Visual Quality Objective provides for the management of proposed activities which are not visually evident. Under the Retention VQO, activities may only repeat form, line, color, and texture which are frequently found in the characteristic landscape. Changes in their qualities of size, amount, intensity, direction, pattern, etc., should not be evident. Immediate reduction in form, line, color, and texture contrast in order to meet Retention should be accomplished either during construction or immediately after. It may be done by such means as seeding vegetative clearings and cut-or-fill slopes, hand planting of large stock, painting structures, etc.

PARTIAL RETENTION (PR)

Management of proposed activities remains visually subordinate to the characteristic landscape according to the Partial Retention VQO. Activities may repeat form, line, color, or texture common to the characteristic landscape but changes in their qualities of size, amount, intensity, direction, pattern, etc., remain visually subordinate to the characteristic landscape. Activities may also introduce form, line, color, or texture which are found infrequently or not at all in the characteristic landscape, but they should remain subordinate to the visual strength of the characteristic landscape. Reduction in form, line, color and texture to meet partial retention should be accomplished as soon as possible after project construction completion or at a minimum within the first year of operation.

MODIFICATION (M)

Under the Modification VQO management of proposed activities may visually dominate the existing characteristic landscape. However, activities which alter vegetative and landform must borrow from naturally established form, line, color, or texture and at such a scale that its visual characteristics are those of natural occurrences within the surrounding area of character type. Additional parts of these activities such as structures, roads, slash, cuts and fills, etc., must remain visually subordinate.

Activities which are predominately introduction of facilities such as buildings, signs, roads, etc., should borrow naturally established form, line, color and texture so that this visual characteristics are compatible with the natural surroundings. Reduction in form, line, color, and texture should be accomplished in the first year of operation.

MAXIMUM MODIFICATION (MM)

Project activities of vegetative and landform alterations may dominate the characteristic landscape. However, when viewed as background, the visual characteristics must be those of natural occurrences within the surrounding area or character type. When viewed as foreground or middleground, they may not appear to completely borrow from naturally established form, line, color or texture. Alterations may also be out of scale or contain detail which is incongruent with natural occurrences as seen in foreground or middleground.

Introduction of additional parts of these activities such as structures, roads, slash, and root wads must remain visually subordinate to the proposed composition as viewed in the background distance zone.

VISUAL ABSORPTION CAPABILITY

1. <u>Landform Diversity</u>. Landscapes of greater diversity or variety have a higher capability to absorb visual modification. Project activities on uniform landforms have a higher potential for creating contrasts in form, line, color, and texture. Also, depending on the observer's position, areas behind rises in topography may not be seen.

2. <u>Aspect Relative to Viewer</u>. The apparent size and visual impact of the __________________ is directly related to the angle between the viewer's line-of-sight and the slope being viewed. As this angle nears 90° to the observer's line of sight, the activity reaches its maximum visual exposure.

3. Slope. The apparent size of the activity is directly related to the vertical angle at which it is being viewed. Project activities on lands with steeper slopes are generally more visible than those on lesser slopes. Also, lesser slopes generally have a higher capability to revegetate after being disturbed than steeper slopes.

4. Aspect. For the latitude of the study areas, the sun's rays strike the soil much more obliquely on the north-facing slopes than on the south-facing slopes. Therefore, more moisture is retained on the north-facing slopes, making their vegetative regeneration potential substantially greater. A project activity on a north-facing slope may meet a higher visual quality objective than the same activity on a south-facing slope because vegetative screening is obtained much sooner.

5. Soil Productivity Relative to Growth Rates. Landscapes with suitable soils, soil depths, and growing conditions have higher capabilities to absorb visual modification than landscapes with soils of low fertility and shallow soils.

6. Potential Soil Color Contrast. Lands with the least color contrasts between subsoils or freshly exposed rock and the existing surface with vegetative colors have the highest capability to absorb visual modification.

7. Soil Stability. Stable landscapes have higher capabilities to absorb visual modification than unstable landscapes due to better vegetative regeneration.

8. Vegetation. Vegetation patterns of even-age stands of trees and landscapes with little variety in vegetative forms, colors and textures have less capability to absorb a visual modification than landscapes with a high percent of vegetation class variety.

9. Vegetative Height and Density. The potential screening ability of vegetation is directly proportional to its height and density. Relatively tall, denser stands of trees have a higher capability to absorb visual modification due to their lower transparency. However, this does not apply when the observer viewing project activities from a higher elevation or viewpoint.

10. Distance. As the distance away from the observer increases, the ability of the landscape to absorb modification increases.

GLOSSARY OF TERMS

AREA OF VISUAL INFLUENCE. That portion of a landscape falling within a person's cone of vision.

BACKGROUND. The area of a distance zone which lies beyond the foreground-middleground. Usually from a minimum of 3 to 5 miles to a maximum of about 15 miles from a travel route, use area, or other observer position. Atmospheric conditions in some areas may limit the maximum to about 8 miles or increase it beyond 15 miles.

BASIC ELEMENTS. The four major elements (form, line, color, and texture) which determine how the character of a landscape is perceived.

LANDSCAPE CHARACTER TYPE. Large physiographic area of land which has common characteristics of landforms, rock formations, water forms, and vegetative patterns.

CHARACTERISTIC LANDSCAPE. The established landscape within an area being viewed. The term does not necessarily mean a naturalistic character. It could refer to a farming community, a rural landscape, a primarily natural environment, or other landscape which has an identifiable character.

CONTRAST. The effect of a striking difference in the form, line, color or texture of the landscape features within the area being viewed.

CULTURAL MODIFICATION. Any man-caused change in the land or water form or vegetation or the addition of a structure which creates a visual contrast in the basic elements (form, line, color, texture) of the naturalistic character of a landscape.

DISTANCE ZONE. The area that can be seen as foreground, middleground, background, or seldom seen. Areas of the landscape denoted by specified distances from the observer. The term is used as a frame of reference to discuss landscape characteristics or activities of man.

FOREGROUND. The detailed landscape found within 0 to 1/4-1/2 mile from the observer.

INTRUSION. A feature (land or water form, vegetation, or structure) which is generally considered out of context because of excessive contrast and disharmony with the characteristic landscape.

LANDSCAPE CHARACTER. The arrangement of a particular landscape as formed by the variety and intensity of the landscape features and the four basic elements (form, line, color, and texture). These factors give the area a distinctive quality which distinguishes it from its immediate surroundings.

LANDSCAPE FEATURES. The land and water forms, vegetation, and structures which compose the characteristic landscape.

MAXIMUM MODIFICATION. A Visual Quality Objective meaning man's activity may dominate the characteristic landscape but should appear as a natural occurrence when viewed as background.

MIDDLEGROUND. The space between the foreground and the background in a picture or landscape. The area located from 1/4-1/2 to 3-5 miles from the viewer.

MODIFICATION. A Visual Quality Objective meaning man's activity may dominate the characteristic landscape but must, at the same time, utilize naturally established form, line, color, and texture. It should appear as a natural occurrence when viewed in foreground or middleground.

OBSERVER POINT. One or a series of observer positions on a travel route or at a use area or a potential use area used to determine seen area.

OBSERVER POSITION. The placement and relationship of a viewer to the landscape which is being perceived.

PARTIAL RETENTION. A Visual Quality Objective which, in general, means man's activities may be evident but must remain subordinate to the characteristic landscape.

PHYSIOGRAPHIC PROVINCE. An extensive portion of the landscape, normally encompassing many hundreds of square miles, which has common qualities of soil, rock, slope, and vegetation of the same geomorphic origin.

PRESERVATION. A Visual Quality Objective that provides for ecological change only.

RETENTION. A Visual Quality Objective which, in general, means man's activities are not evident to the casual forest visitor.

SCENIC AREA. An area whose landscape character has a high degree of a variety, harmony, and contrast among the basic visual elements, which result in a landscape pleasant to view.

SCENIC QUALITY. The degree of harmony, contrast, and variety within a landscape.

SEEN AREA. That portion of the landscape which can be viewed from one or more observer positions. The extent or area that can be viewed is normally limited by landform, vegetation, or distance.

SENSITIVITY. As applied to visual resource management, that degree of concern expressed by the user toward scenic quality and present or proposed visual change in a particular characteristic landscape.

USE VOLUME. The total volume of visitor use each segment of a travel route or use area receives.

VARIETY CLASS. The value (A, B, or C) assigned to a scenic quality rating unit by applying the scenic quality evaluation key factors which indicate the relative visual importance of the unit to the other units within the same physiographic region.

VIEW. Something, especially a broad landscape or panorama, that is looked toward or kept in sight. The act of looking toward this object or scene.

VISUAL ABSORPTION CAPABILITY (VAC). An estimate of the relative ability of a landscape to withstand land manipulation activities without affecting its visual character or integrity.

VISUAL MANAGEMENT SYSTEM (VMS). The planning, design, and implementation of management objectives to provide acceptable levels of visual impacts for all USFS resource management activities.

VISUAL QUALITY OBJECTIVES (VQO). Indicates the degree of visual change that is acceptable within the characteristic landscape. It is based on the physical and sociological characteristics of any given homogeneous area and serves as a management objective.

VISUAL RESOURCE. The land, water, vegetative, animal, and other features that are visible on all lands (scenic values).

VISUAL SENSITIVITY LEVEL(S). An index of the relative degree of user interest in scenic quality and concern and attitude toward present or proposed changes in the landscape features of an area in relation to other areas in the planning unit.

APPENDIX C-8
CULTURAL RESOURCE AFFECTED ENVIRONMENT
IN THE HD MOUNTAINS STUDY AREA

APPENDIX C-8

CULTURAL RESOURCE AFFECTED ENVIRONMENT
IN THE HD MOUNTAINS STUDY AREA

Data for the HD Mountains Study Area in the San Juan National Forest were compiled through an extensive review of archaeological literature and professional consultation.[1] Some 448 sites were determined to have been documented in the area from a wide range of sources. Information on each site was checked, rechecked, and catalogued in a computer database which recorded several critical variables such as location, topographic context, site type, cultural period, and cultural management status. These data were then used, along with master site plot quadrangle maps, in evaluating site distributions and densities in the HD Study Area. Both the site plot maps and the database were combined with U.S. Forest Service map overlays of archaeological survey boundaries to produce cultural resource maps contained elsewhere in this report (Section 3.7-Affected Cultural Resources Environment). These data have been further analyzed in the following sections to construct an overview of the affected cultural resource environment in the HD Mountains Study Area.

CULTURAL CHRONOLOGY FRAMEWORK

Current cultural resource data show that human occupation of the HD Study Area and its surrounding region dates back at least ten thousand years. Over the past several decades, a number of cultural classification schemes have been applied to the general area. However, a recent synthetic overview of cultural development in Southwest Colorado has provided us with a basic cultural framework model. That framework is presented below in Table C-8-1 with modifications from regional Navajo Reservoir and Chimney Rock studies to fully reflect local phase variations for the project area.

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1 Research sources for the HD Project included the following: Extensive report and site file searches at the Colorado State Historic Preservation Office(SHPO), Denver Colorado; report searches, computer file searches, and extended use of SHPO survey files, site data printouts, and quadrangle map overlays of the U.S. Forest Service, San Juan National Forest, Durango, Colorado; and professional consultation with Mr. Gary Matlock, San Juan National Forest chief archaeologist; Richard Bell, San Juan National Forest, Pine District; Dr. Susan Collins, Colorado State Archaeologist; and Dr. Gordon Tucker, archaeologist with Powers Elevation Co., Inc., Denver, Colorado.

TABLE C-8-1
CULTURAL STAGE, PERIOD AND PHASE FRAMEWORK FOR THE HD MOUNTAINS PROJECT

DATE BC/AD	PALEO-INDIAN STAGE (COMPLEXES)	ARCHAIC STAGE/OSHARA TRADITION (PHASES)	FORMATIVE STAGE/PECOS CLASSIFICATION (PERIODS)	NAVAJO RESERVOIR/ CHIMNEY ROCK (REGIONAL PHASES)
-BC-				
10,000	CLOVIS			
9000	FOLSOM			
8000	PLANO (EARLY)			
7000	PLANO (MID)			
6000	PLANO (LATE)			
5000		JAY/BAJADA		
4000		BAJADA		
3000		SAN JOSE		
2000		ARMIJO		
1000		EN MEDIO		
500			BASKETMAKER II	
AD 1		V	V	LOS PINOS
500			BASKETMAKER III	SAMBRITO
700			PUEBLO I	ROSA
850				PIEDRA
1000			PUEBLO II	ARBOLES/ CHIMNEY ROCK
1100			PUEBLO III	
1200			V	HD REGION OCCUPATION DATA INSUFFICIENT
1300			PUEBLO IV	
1400				EARLY V ATHABASCAN-SHOSHONEAN GROUPS
1500			V	
1600			PUEBLO V	NAVAJO (GOBERNADOR PHASE)
1700				SPANISH-AMERICAN EXPLORERS/SETTLERS
1800			V	HISTORIC UTE TRADITION
1900				EUROPEAN-AMERICAN SETTLEMENT

Sources: Eddy 1966, 1977; Eddy, Kane and Nickens 1984: Figure 2.2.

As noted earlier, Colorado's recently standardized cultural classification system includes the archaeological concepts of stage, complex, period and phase. Briefly, each of these terms, as used in the following text, are defined as:

STAGE - a broadly similar cultural and socio-economic lifestyle and level of technology over an extensive, multi-regional geographic area. Within stages, human populations utilize generally similar adaptive strategies and forms of technology. Stages are only loosely time-dependent and different stages often have existed contemporaneously in the past.

PERIOD - a defined span of time in which human groups in a specific geographic region, or set of regions, share comparable technologies and lifestyles. In North American Archaeology, periods are often seen as regionally defined sub-divisions of longer and broader cultural stages.

COMPLEX - a group of technologically defined culture traits that are characteristic of one or more contemporaneous human populations. Cultural complexes are generally narrow definitions of prehistoric groups whose overall archaeological characteristics are poorly known. In some cases, the term complex is used interchangeably with that cultural period.

PHASE - an archaeological unit defined by a detailed database of technical and socio-economic traits in a geographically localized sub-population of a larger, more widespread cultural tradition. Phases are usually defined for specific regions or sub-regions where geography favors strong cultural interaction and development of minor, but important, independent traits of the more broadly shared culture tradition.

Cultural history in the HD research area is characterized by nearly the full range of human habitation known to North America. Archaeological site densities are generally high, often rivalling much better known regions to the west, such as Mesa Verde or Hovenweep. The primary traits of cultural stages, periods, and phases, as set forth in the preceding chronological table, are summarized as follows for the HD project area:

Paleo-Indian Stage(10,000-5000 B.C.)

The Paleo-Indian Stage in the American Southwest dates back to Late Pleistocene times and continued into the Early Holocene. Native American populations in the region were small and characterized by nomadic hunting and gathering lifestyles, heavily involved in the exploitation of large, now mostly extinct, Ice-Age

mammals such as mammoths, camels, horses, and giant ground sloths. Artifacts from Southwest Paleo-Indian sites indicate that plant food exploitation, while important, appears to have been secondary to hunting.

The Paleo-Indian Stage in the Southwest is usually divided into three major complexes, or periods: the *Clovis Complex*, dated between 10,000 and 9,000 B.C., the *Folsom Complex*, dated to 9000-8000 B.C., and the *Plano Complex(es)*, dated between 8000 and 5000 B.C. All three complexes are defined largely by distinctive projectile point types, or classes of types, which tipped shafted, thrusting, throwing, or atlatl-assisted throwing spears or darts.

The Clovis Complex is probably the most comprehensively documented Paleo-Indian complex in the Southwest. Actual mammoth and bison kill localities are known from Eastern New Mexico and Southeastern Arizona. Campsites and isolated point finds are ubiquitous through most of the American Southwest. However, Clovis finds have yet to be reported from Southwest Colorado although individual points are known from the northern San Juan Basin, less than a hundred miles from the HD Study Area (Judge 1982; Reher 1977: 401, Fig.11.9)

The Folsom Complex is moderately well-represented in the Southwestern United States. It is characterized by hunting kill sites where a large Late Pleistocene species of bison was often ambushed in small herds and individually. Folsom hunters also exploited many lesser animal species such as camels, horses, and deer along with the seasonal collection of wild plant foods. The Folsom complex lasted around a thousand years and disappeared as a distinctive culture by around 8000 B.C. Its primary distinguishing artifact is the finely-made, lanceolate-shaped and channel-flake thinned Folsom projectile point. A more poorly-known point type, that of the Midland point, appears contemporary with the Folsom Complex and, in many archaeologist's view, is probably a non-channel flaked version of the more common Folsom point.

To date, Folsom sites have only been documented from the far eastern areas of the Southwest, in Eastern New Mexico. Several significant Folsom camp and kill sites are known from the San Luis Basin, some 150 miles east and northeast from the HD Study Area, on the eastern side of the Rocky Mountain Continental Divide (Dawson and Stanford 1975; Emery and Stanford 1982). Surface finds of Folsom points are fairly common in the Northern Southwest. Several Folsom points are documented from the northern San Juan Basin immediately southwest of the HD Study Area and a partial point was recovered in the Navajo

Reservoir project immediately south of the HD Project.[2] Further west and southwest, Folsom points have been reported as surface finds at numerous localities in eastern Utah and northern Arizona (Crouse 1954; Huckell 1982; Hunter and Tanner 1960).

The Plano Complexes, often sub-divided into periods of Early, Middle, and Late, are extremely rare in the Southwest. As a group, Plano Complexes are defined by several distinctive lanceolate and stemmed to unstemmed projectile points, all characterized by parallel-flaking, even removal of thin flakes from blade edges to met in both point face's centers. Early and Mid Plano point types are horizontally parallel-flaked while Late Plano point types have oblique parallel-flaking. Plano sites, only documented from the more northerly and easterly plains regions, are often associated with small to large herd bison kills, occasionally ambushes or drives which destroyed hundreds of animals.

Significant Plano sites are mostly documented from the far eastern boundary of the Southwest Region, mainly in the plains and mesas of Eastern New Mexico although some recent Plano sites have been reported from South Central New Mexico. Until recently, in Southwest Colorado, only two Plano points had been adequately documented. These were the surface find of a Milnesand projectile point from Mesa Verde and an unidentified parallel-flaked point fragment from the Dolores Archaeological Program (Hayes 1964; Kane 1983: 27). In 1988-89, survey data and artifacts of the San Juan National Forest region were analyzed to determine the presence of Paleo-Indian localities.[3] A preliminary report of that study has concluded that as many as a dozen Paleo-Indian projectile points, most of Plano origin, were collected and documented in various surveys. The San Juan Forest study is particularly interesting in that tool material analyses of the Paleo-Indian points indicates the possibility that most may have been manufactured regionally in Southwest

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[2] For San Juan Basin Folsom finds, see Judge 1982 and Reher 1977. The Navajo Reservoir Project point was a talus slope surface find. See Dittert, Hester and Eddy 1961: 172, 205, fig.43p. In 1984, recovery of a possible Folsom from the floor of an arroyo in the Crowbar Creek drainage was reported by a local landowner. However, the point was given to a relative and its Paleo-Indian cultural affiliation was never confirmed. Subsequently, a bone, identified as bison, was recovered from the same arroyo by a survey by Archaeological Consultants of Durango, Colorado. Association of the bison with the absent point was not possible, but their proximity may suggest that Paleo-Indian remains could be buried below several feet of sediments in the HD Study area.

[3] An early report of the study was given at the 1990 Conference of the Colorado Council of Professional Archaeologists at Dolores, Colorado, on March 9 (York 1990). At least three Plano point types appear to be represented: Agate Basin, Milnesand, and Jimmy Allen. A fourth point type may be either Hell Gap or more likely, based on this author's examination of the point's photograph and line illustration, an Early Archaic Jay point.

Colorado. However, it should be noted that none of the San Juan Forest study points derived directly from the current HD Study Area. Those points discovered closest to the project area came from the western edge of the San Juan National Forest northeast of Pagosa Springs, Colorado.

The scarcity of Plano sites and artifacts in the American Southwest, including the HD Study Area, is likely due to expansion of a significant drying and warming climatic episode, often called the Altithermal, which spread slowly eastward from the California Deserts and the Great Basin after 8000 B.C. By the Plano Complex time period, environmental conditions for Plano lifestyle fauna, the bison herds of the more easterly plains, were probably quite marginal. Current finds of individual Plano points in the Southwest are likely to be the result of visiting Plano groups from the Northern and Southern Plains.

<u>Archaic Stage (6000 B.C.-400 A.D.)</u>

The Archaic Stage in the project area almost certainly overlaps the Paleo-Indian Late Plano Complexes of the more easterly and northerly plains regions. By 6000 B.C., climatic desiccation and warming gradually reduced both animal and plant resources significantly. Human populations of the early Archaic were forced to adapt to a more generalized hunting and gathering lifestyle based extensively on broad-spectrum plant collection and processing. This is particularly well-documented by an increase in plant processing tools, including grinding stones and plant fiber working lithics. Initially, in the early centuries of the Archaic, Southwest human populations were apparently limited in number and characterized by seasonal migratory nomadism. Warm and dry Altithermal conditions began to ease around 3000 B.C. and environmental conditions led to higher natural resource densities. Accordingly, human populations slowly increased and developed more efficient skills in exploiting the expanded plant and animal resources. Not only are artifacts better made, more versatile and numerous after this time, but there is good evidence for greater sedentism and larger social groups, particularly during the winter months. Late in the Archaic Stage, sometime after 2000 B.C., there is evidence that a primitive domestic corn made its appearance in the Northern Southwest, having been imported from Mexico. However, the use of corn for food production appears extremely sparse and sporadic until the turn of the millennium, after A.D. 1.

Our knowledge of northern Southwest Archaic cultures is still very poorly documented, although that database has grown substantially with recent archaeological projects in the San Juan Basin. The HD Study Area's Archaic components appear to be heavily linked to the latter part of the Oshara Tradition, first documented by the Eastern New Mexico University's Anasazi Origins Project in New Mexico's Arroyo

Cuervo region.[4] The Oshara Tradition was first proposed by Cynthia Irwin-Williams in the early 1970s as the definitive cultural sequence of the Northern Southwest's Archaic Stage which ultimately led to the subsequent Anasazi Tradition of the Formative Stage. Primary cultural developments of the Oshara Tradition were organized by Irwin-Williams into successive developmental time periods she termed "phases," although the archaeological concept of "period" is probably more appropriate. Oshara Tradition phases include:

Jay Phase (5000-4800 B.C.) - This early Archaic phase is still poorly known and documented. Jay sites are small and ephemeral and imply small-group nomadic hunting-gathering in a fairly desiccated Southwest landscape. The primary diagnostic tool is an often crude and thick stemmed projectile point. Other artifacts include non-diagnostic scrapers, bi-facial knives and hammerstones. Site locations emphasize the need for water and tended to be located along damp sheet-sand deposits, ephemeral ponds, and stream and spring localities. A stemmed point which closely fits Jay type parameters was recently documented in a study of Paleo-Indian archaeology of the San Juan National Forest.[5] However, that particular point, recovered from northeast of Pagosa Springs, Colorado, has also been identified as a possible Hell Gap point belonging to the Paleo-Indian Plano Period. Regionally, Jay sites are known from North Central New Mexico, including the San Juan Basin and the East Puerco River valley. Jay points were originally identified as the Rio Grande point type in the 1940's and were discovered as surface finds in the Upper Rio Grande River Valley, including Colorado's San Luis Valley (Perino 1968: 78, Plate 39).

Bajada Phase (4800-3200 B.C.) - This early Archaic phase is also poorly known and documented. There is some evidence that environmental conditions worsened during the Bajada Phase. Even so, the overall number of Bajada sites increase slightly in north central and Northwest New Mexico. The nomadic plant-food intensive lifestyle of the early Jay Phase continued, but overall adaptive efficiency appeared to improve.

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4 A recent analysis of projectile points from the HD Mountain region documented several Archaic Stage points, most belonging to the Oshara Tradition centered in New Mexico to the south (Mortorano et al. 1985: 94-99). However, as also noted in the study, some of the analyzed point types are also quite similar to Uncompahgre Complex examples, mostly from that complexes' Mid-Archaic Monitor Mesa Phase. For the purposes of this report, however, Archaic sites, defined solely by projectile points will be identified with phases of the Oshara Tradition. Reasons for this identification includes the greater access of New Mexico cultural groups with the south-flowing river corridors of the HD region. Good sources for the Northern Southwest Archaic, and the Oshara Tradition in particular, are found in Irwin-Williams 1973, 1977, and Simmons 1981.

5 Projectile point No. 10 in York 1990.

In addition to small ephemeral camps, probable longer term camping stays are indicated by the presence of small hearths and earth oven pits. The basic lithic tool kit remained much the same as in the Jay Phase with the addition of unifacial and bifacial choppers. Also, the earlier Jay point was replaced by a better-made stemmed and concave-based Bajada projectile point.

San Jose Phase (3200-1800 B.C.) - Environmental conditions in the northern Southwest gradually improved during the San Jose phase. There was a gradual increase in the number of sites, indicating a concomitant increase in overall human population. An improving environment and growing resource base allowed a modest degree of sedentism, mostly during the winter months. Site sizes increased and semi-permanent huts or wickiup structures are evidenced by post-hole patterns. Site locations tended to be fairly short-term open-air camps with ready access to water. Heated rock cooking pits and basin hearths were present. Increased faunal remains of moderate to small sized game support climatic data on a growing bio-mass resource base. The primary diagnostic San Jose Phase tool was a series of medium to small, finely-made, stemmed and concave-base projectile points. The points are often finely serrated, a trait cited as evidence for their multiple use for weapons and as knives for plant and animal product processing. Important additions to the San Jose Phase tool inventory were the first Archaic grinding and hand stones for plant seed and nut processing. Both flat and basin-style grinding stones are found, but grinding stones predominate.

San Jose Phase sites and isolated point finds are the first significant evidence of Archaic peoples in southwestern Colorado. Isolated point finds and sites, which represent mostly short-term camp and quarry/lithic workshop sites, belonging to the phase are scattered from the Dolores Plateau southward to Mesa Verde and eastward to Chimney Rock, east of the HD Mountains Study Area. Some of the best survey documentation for San Jose Archaic sites in southwest Colorado comes from studies in the Ridges Basin area near Durango and the Dolores Valley region.[6] Although a thorough analysis of Colorado San Jose sites and artifacts has not yet been accomplished, it has been suggested that Colorado "uplands" served as a seasonal resource territory for San Jose populations wintering in the San Juan Basin.

Armijo Phase (1800-800 B.C.) - The Armijo Phase shows the first evidence, though slight, of the appearance of domestic corn in the northern Southwest. Borrowed from Mexico, where corn had been domesticated somewhat earlier, Armijo Phase populations slowly incorporated domestic corn into their subsistence

[6] Eleven Archaic sites were identified in Ridges Basin between the Animas and La Plata Rivers(see Ware 1981: 24-25). In the Dolores Region, several seasonal camps and special activity sites were recorded during the Do2lores Archaeological Program of the 1970's (see Kane 1984: 26).

inventory.[7] There is limited evidence that Southwest environments underwent modest stresses from cyclical drying and warming during the Armijo Phase, possibly encouraging the adoption of corn cultivation to a still overwhelmingly hunting-gathering economy. The slow adoption of a mixed wild food foraging and a minor domestic food production economy appears to have stimulated more effective cultural adaptation and modest population growth in the northern Southwest.

Sites belonging to the Armijo Phase were mainly seasonal, ephemeral camps and activity areas, but larger, longer term, wintering camps and occupied cave shelters are also found. In northern New Mexico, larger, more sedentary appearing site localities have been found to cluster in well-watered stream and spring locations, including water-retaining sheet dunes in headwater areas, where simple horticulture could be easily practiced. Site sizes tended to increase and seed (and grain) processing grinding tools were more and more common. The overall number and complexity of Armijo sites in Northern New Mexico also increased, hinting at an expanding population in that area. Diagnostic projectile points were evolved versions of the earlier San Jose types with more common traits of shorter, widely expanding stems and straight to concave bases. Projectile point blade serration also increased as a distinctive Armijo projectile point trait.

Unlike the earlier San Jose Phase, there is little evidence of even seasonal Armijo exploitation of the southwest Colorado mountains, river valleys, mesas and plateaus. However, much of this lack of evidence may be due to difficulty in distinguishing late San Jose and Armijo projectile point types. At least two possible Armijo site components were documented in University of Northern Colorado surveys in the HD Study Area in 1984 and 1985 (Brunswig 1986).

En Medio Phase (800 B.C.-400 A.D.) - Definition of the En Medio Phase is largely restricted to minimally reported research of Eastern New Mexico University's *Anasazi Origins Project* in the north central New Mexico's Arroyo Cuervo region during the mid and late 1960's. Its exact content and context in southwestern Colorado is essentially unknown. It is probable, though, that developmental traits of the early En Medio Phase, increasingly intense application of domestic corn, and eventually beans and squash, horticulture to archaic hunting-gathering subsistence also happened in southwest Colorado.

The En Medio Phase, as defined by its creator, Cynthia Irwin-Williams, is essentially a transitional evolution from an Archaic (hunting-gathering) lifestyle to a Formative lifestyle based on a mix of domestic food

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7 Although there is some controversy about the presence of corn in Armijo contexts, maize pollen has been recently found sealed in a hearth radiocarbon-dated to the phase (See Simmons 1986).

production and wild food foraging. Further, later developments of the phase, defined in New Mexico's Arroyo Cuervo region, both chronologically and developmentally duplicate early Formative Anasazi Basketmaker culture history and process in the Four Corner's region. In dealing with this problem, only the early part of the En Medio Phase, between 800 B.C. and 1 A.D. will be defined here as the closing cultural development of the Archaic Stage for the HD Study Area. Later developments of the Oshara Tradition's En Medio Phase will be included under subsequent discussion of the Anasazi Basketmaker Periods.

The Early En Medio Phase is characterized by a growing sedentism made possible by storable food surpluses in the form of domestic corn and, by 400 B.C. to 1 A.D., the addition of beans and squash in some areas of the northern Southwest. Southwest environmental conditions, with greater effective moisture, existed throughout the Early En Medio Phase. Below-ground food storage cists and well-made basin-style grinding stones attested to the growing importance of domestic foods in the Late Archaic economy. Seasonal migration to diverse wild plant and animal resource zones was still an important factor in En Medio lifestyle. However, there is some evidence that well-established winter camps may have been "manned" by some individuals to care for summer domestic crops. By at least 250 B.C., the first shallow pit house communities were being built in New Mexico's San Juan Basin and the canyons of Northeastern Arizona. In some cases, former rock shelter camps were modified to contain shallow pit houses, often with external, lined, storage cists and protective stone walls.

Along with a growing cultural inventory of domestic-oriented plant processing tools, projectile point types changed from leaf-shaped or triangular, serrated Armijo points to large, corner-notched, dart points. These En Medio projectile point types continued in essential form and style as Basketmaker II and III point types in the subsequent Formative Stage.

Early En Medio Phase sites have yet to be identified in southwest Colorado, including the HD Study Area. One explanation may be that, as in the earlier Archaic phases, much of southwest Colorado may have been a seasonal resource territory with major wintering localities being situated in the canyon and mesa regions of northern New Mexico. Another possibility is that Early En Medio components are obscured by, or even confused with, subsequent, later, and essentially identical Anasazi Basketmaker components.

Formative Stage (A.D. 1-1450)

The Formative Stage signals an effective transition from a predominantly nomadic, hunting-gathering lifestyle to one based on mixed agriculture and wild food foraging with a fixed-base, essentially full-time, sedentism. In southwest Colorado, including the HD Study Area, early Formative pithouse settlements developed into various-sized communities constructing and using surface storage and living roomblock units we call pueblos. Late in the Southwest Formative Stage, pithouses, referred as kivas in their new "form", were being used mainly for specialized community, religious, and social group functions. Some regional pueblo settlements, late in the Formative time period, coalesced and grew into substantial villages and towns housing hundreds of people and serving as ceremonial and market centers for outlying smaller villages and individual homesteads.

Early Formative Stage cultural developments took place at a time of very good environmental conditions. However, by around A.D. 600, in much of the northern Southwest, climatic conditions began to deteriorate in a series of climatic cycles which encouraged adaptive shifts in many regions toward more effective domestic food production strategies. In most cases, these strategies required greater cooperation among families and existing small communities and more complex cultural infra-structures. Technologies and socio-economic strategies were developed in a wide range of areas to maintain effective social control, economic viability, and overall effective adaptations to fluctuating and changing regional environments. By A.D. 1300, effective social and cultural adaptation of northern Southwest Formative populations appears to have finally failed to compensate for negative environmental and growing socio-economic forces. In general, the entire northern Southwest region was effectively abandoned, at least by native peoples with mixed agricultural and hunting-gathering lifestyles, by that time. After A.D. 1300, the region never again was home to such a large and successful human population and culture.

The primary cultural framework of the Formative Stage in the HD Study Area is the broadly-based Pecos Cultural Classification. The Pecos Classification was first formulated by a group of Southwest archaeologists at the 1927 Pecos Pueblo Conference. Since that time, the classification has been modified and refined as a framework for Formative culture history for the Northern Southwest. The Pecos Classification deals explicitly with a Formative phenomenon known collectively as the Anasazi Tradition and defines distinctive, evolutionary cultural developments of that tradition over time. While the Pecos Classification remains generally valid for the Northern Southwest, localized intensive research in some areas, including the HD Project region, have resulted in finer detail sub-sets, called "phases," of the overall Pecos Culture History. The current Anasazi phase system in operation for the HD Project region is that of the Navajo

Reservoir/Chimney Rock Sequence.[8] The following sections briefly summarize the primary traits of the Anasazi Tradition and its regional phases in the HD Study Area.

Basketmaker II/Los Pinos Phase(A.D. 1-400) - The Los Pinos Phase is the local version of the Pecos Basketmaker II Period in the HD Region. Los Pinos sites generally consist of dispersed shallow pithouses located on the crests of low knolls, secondary terraces, or benches overlooking river and tributary stream drainages. Living sites range from single habitation units to less common multiple and village complexes of up to eleven pithouses.

Los Pinos pithouses were shallow, a few inches to a couple of feet deep with a circular wood-post, clay-covered superstructure. Pithouses from this phase were either single rooms or a combination of a main room with an attached antechamber. Sub-surface slab-lined storage pits and a central hearth were common in the main chamber. Some Los Pinos pithouses were circled with cobble-flagged rings. Settlement areas include exterior pit ovens and a generalized scatter of lithic and charcoal debris.

Los Pinos artifacts consist of crude stone core-tools, flake tools, and both basin and single open-ended basin grinding stones. Projectile points are large, triangular, corner-notched types. Ceramics are rare, but occasionally present. They include a "false" pottery, a crude unfired vegetable matter-tempered gray ware, and a crude, hand-coiled and scraped brownware known as Los Pinos Brown.

Subsistence was a mix of wild plant and animal food foraging and a lesser component of agriculture, primarily corn, on present evidence.

No sites of proven Los Pinos age are documented within the boundaries of the HD Study Area. Navajo Reservoir Project surveys of the early 1960s, however, revealed Los Pinos remains in the lower Pine River. Also, in the 1950s, a private archaeological survey and a pipeline survey near Ignacio broadly documented the relatively common presence of single and multiple unit Los Pinos sites from Vallecito Reservoir in the Northern Pine River Valley to the confluence of the Pine and San Juan Rivers in the south (Green 1954; Eddy, Kane and Nickens 1984). In fact, an 1984 overview of Anasazi cultural history in the Pine River Valley prompted speculation that the area was a "distributional center of the Los Pinos Phase...". (Eddy,

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[8] The Navajo Reservoir phase sequence was developed through major salvage survey and excavation work in the late 1950's and early 1960's (See Dittert, Hester and Eddy 1961; Eddy 1966, 1972). The sequence was further refined by University of Colorado research at Chimney Rock, immediately east of the HD Study Area, in the 1970's (See Eddy 1975, 1977).

Kane and Nickens 1984: 79). East and southeast of the HD Mountains, no Los Pinos sites have been found in the Piedra River drainage and only a handful of sites are known from the San Juan drainage, the latter all occurring south of the Colorado-New Mexico border.

Basketmaker III/Sambrito Phase(A.D. 400-700) - The HD Mountains region's local Basketmaker III phase is called Sambrito. Sambrito Phase culture traits are very similar to those of the preceding Los Pinos Phase. Site locations are essentially the same, along river and stream secondary terraces, ridge knolls, and benches. Shallow pithouses are the primary type of living structure. A few Sambrito Phase sites excavated during the Navajo Reservoir Project also revealed the development of rare, larger, and more complex pithouses that may have served community-wide social and ceremonial functions.

Subsistence was the same as in the preceding phase, with a possible small increase in reliance on food production versus wild food foraging. Growing importance of domestic corn in the Sambrito diet is shown by an increase in sub-surface storage cists.

Material culture of the Sambrito Phase includes a single brownware called Sambrito Brown. Extremely rare plain trade graywares from the Mesa Verde region, Chapin Gray, and Twin Trees Plain were recovered from a single Sambrito site in the Navajo Reservoir District south of the HD Study Area. Projectile points change from large triangular, corner-notched types to small, triangular, corner-notched types with a tendency for unthinned bases. Earlier basin grinding stones completely disappeared, to be replaced by single open-ended trough metates. Both the number and overall quality of lithic tools for plant-, bone- and wood-working increased in the Sambrito Phase.

No Sambrito sites are definitively documented from the immediate HD Study Area, although survey reports consistently refer to Basketmaker III sites. Most of these identifications are based on the presence of plain graywares, often identified as Chapin or Lino Gray types, commonly associated with Basketmaker III components in the Durango and Mesa Verde regions to the west. However, based on the Navajo Reservoir Sambrito/Basketmaker III phase definition, this grayware association would be unlikely to identify a Sambrito Phase component in the HD area. Their presence is more likely to characterize the succeeding Pueblo I/Rosa Phase component. The closest Sambrito components to the HD area are Todosio

Rockshelter burials in the lower Pine Valley and some distance to the south and east, in the San Juan River drainage near Arboles, Colorado.

Early Pueblo I/Rosa Phase(A.D. 700-950) - The Anasazi Pueblo I Period is represented by two closely related local phases. The first of these is the Rosa Phase. Habitation sites during the Rosa Phase include single-unit "homesteads, multiple-unit sites with 2 to 5 pithouses, and village units composed of 6 or more pithouses. The primary architectural structure, as in earlier Anasazi phases, was the pithouse. Some small, shallow style pithouses were retained from earlier times, but two other styles appear: larger, deeper, but still simple versions of the Basketmaker pithouse, and a deep, large style with alcove recesses, partial or fully encircling benches, and floor "sipapu" holes. In the last half of the Rosa Phase, single or multiple room wood-post surface buildings with clay-covered interwoven branch walls were being built. Known as "jacal" buildings, these structures were used initially for food storage and formed a crescent-shaped row of rooms north or west of pithouses. By the end of the Rosa Phase, these food storage rooms were gradually being enlarged and adapted for human occupation and indoor activity areas. In addition to habitation sites, a large number of limited-activity sites are associated with Rosa Phase sites. These include many found in earlier times, hunting camps, plant processing stations, lithic quarries, and possible field camps in more distant areas of restricted, but still valuable, agricultural soils.

Rosa Phase site excavations in the Navajo Reservoir District show a substantial reliance on corn-beans-squash agriculture along with a significant component of wild food foraging.

Cultural materials consist of a wide range of hunting and gathering lithics, along with an increase in grinding stone tools. Side-notched axes are abundant, testifying to an increased need for wood as a building material. The presence of small, finely-made, triangular, corner-notched projectile points indicate the use of the bow and arrow as a hunting weapon in preference to hand or atlatl(throwing stick) thrown darts. Ceramics become extremely abundant and include three major types: a plain Rosa Gray, a so-called Rosa Black-on-White decorated ware with a glazed variety, and a rare Sambrito Brownware-derived ceramic type known as Rosa Brown. Imported pottery from the San Juan Basin and the Mesa Verde region are rare, but include Chapin Gray, La Plata Black-on-Red, San Juan Red Wares, and Abajo Red-on-Orange.

Rosa Phase sites are extremely abundant in the HD Study Area, particularly on the western side of the HD Mountains. Some sites are known from the immediate vicinity of the Pine River, but most appear to be concentrated in the lower tributary drainages of that river. Habitation sites tend to concentrate in the lower stream drainages while limited-activity sites are the most common site type found in the uppermost sections

of Pine River tributary stream valleys and canyons. Rosa sites are present, but much less common on the eastern side of the HDs, in the Piedra River Valley. Further east and south of the project area, Rosa sites are very abundant in the San Juan River drainage from its upper reach to at least the Colorado-New Mexico state line.

Late Pueblo I/Piedra Phase (A.D. 850-950) - The Piedra Phase is a time of important change in the HD region. Stressed by a growing environmental deterioration, Anasazi populations appear to have undergone substantial physical dislocation and cultural change. Throughout the region, habitation sites became both fewer and larger in size. Pithouses were mostly the larger and more elaborate style first found in the preceding Rosa Phase. Surface buildings became more elaborate and complex, often built of mortared stone. In many cases, jacal surface roomblocks were used as living structures in preference to pithouses. During the Piedra Phase, the first true communal kivas were constructed. Some settlements in the Navajo Reservoir District, south of the HD Mountains, reflect socio-economic stress in evidence of fortified stockades, burned houses, and group massacres, occasionally characterized by cannibalism.

The Piedra culture inventory differs only moderately from the preceding Rosa Phase. Large numbers of grinding stones and the appearance of groundstone hoes emphasize the importance of corn in the Piedra economy. Early in the Piedra Phase, single open-ended trough metates were replaced by flat slab grinding stones. Small corner-notched points were also gradually replaced; with small, *side-notched* triangular point types. Ceramics include a Piedra Gray ware, a decorated Piedra Black-on-White and an early Piedra neck-banded pottery which was eventually replaced by Mancos Gray and Payan Corrugated wares in late Piedra times. The primary difference between earlier Rosa Gray and Black-on-White graywares and Piedra Gray and Piedra Black-on-White graywares is the use of quartz sand temper in Rosa types and a crushed andesite rock temper in Piedra types. Early in the Piedra Phase, the most common imported ceramics were Abajo Red-on-Orange and San Juan Buff Black-on-Red. However, a growing relationship with the San Juan Basin is attested in Late Piedra times by a predominance of Cortez Black-on-White, Kana-a Black-on-White and Red Mesa Black-on-White wares.

Evidence for the presence of Piedra Phase populations in the HD Study Area is somewhat fragmentary. On the western side of the HD Mountains, in the Pine River Valley, only a few limited-activity sites with pottery can be definitively be called Piedra. For the most part, it appears the Pine River drainage was largely depopulated by early Piedra times. On the eastern side of the HD Mountains, the number of Anasazi sites increased slightly, although the majority of Piedra sites within the HD Project boundaries are mostly

ephemeral limited-activity sites. Piedra habitation sites are most heavily concentrated along the Piedra River immediately below the Southern Ute Reservation boundary south to the Colorado-New Mexico border. Navajo Reservoir and University Colorado surveys have documented a substantial outmigration of Piedra Phase peoples from the Navajo Reservoir District towards of the headwaters of the Piedra and San Juan Rivers.[9] Presumably, most of the former Pine River Valley Anasazi population ended up as a part of these migrations into the Piedra and San Juan upper reaches.

Pueblo II/Arboles Phase (A.D. 950-1050) - Culturally, the Arboles Phase is a mixture of Pueblo I and Pueblo II traits. Settlement types largely consist of single- and multiple-unit habitation settlements. The larger village-size units of the previous Piedra Phase seem to be lacking. Large, fairly elaborate pithouses and substantial surface masonry roomblocks are the main architectural style. Early in the Arboles Phase, masonry multi-room pueblos replaced pithouses as the primary living structure. Communal kivas are absent from Arboles sites.

The overall material culture inventory is little changed from the Piedra Phase. Arboles ceramics include a plain grayware, a decorated Black-on-White ware, and Mancos and Payan Corrugated wares which appeared at the end of the Piedra Phase. Corrugated wares, however, disappear by the mid-point in the phase, around A.D. 975. Imported ceramics, like La Plata Black-on-Red, Cortez Black-on-White and Red Mesa Black-on-White, indicate significant interaction with the Chacoan Anasazi populations of the Central San Juan Basin. There is slim artifactual evidence, in the form of more animal bone and antler tools, that reliance on wild animal and plant foods may have increased despite a lowering of natural resources due to the drier and warmer Arboles environment. Certainly, arable land erosion and a less reliable climate contributed to a weaker agriculture-based economy.

With continued environmental adversity and further headward erosion of the San Juan and Piedra River floodplains, Arboles sites became heavily concentrated in the mid-upper reaches of the Piedra and San Juan River Valleys, mostly within present-day Colorado. There is little evidence of an Arboles presence west of the HD Mountains, except for a few possible Arboles hunting and plant processing camps in the Pine River foothills. Only a handful of Arboles Phase sites are located in the Piedra River Valley on the immediate eastern periphery of the HD Study Area.

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[9] Eddy (1972,1974) considers this population relocation as being due to environmentally induced headward erosion of arable floodplain soils in the Piedra and San Juan River Valleys. However, there is, as yet, no adequate basis for explaining the virtual abandonment of the Pine River Valley by early Piedra Phase times.

Pueblo II/Chimney Rock Phase (A.D. 950-1125) - The Chimney Rock Phase overlaps and succeeds the Arboles Phase in the HD Project region. It represents the integration of local Arboles populations into a hybrid Arboles/San Juan Chacoan Anasazi phase through direct interaction with Chacoan Anasazi populations to the south and southwest. Trade wares and a number of culture trait developments during the Piedra and early Arboles Phases indicated intensifying contact with Chacoan peoples of the San Juan Basin. Sometime around A.D. 1075, based on tree-ring dates, Chacoan migrants, perhaps trader-priests, moved into the upper reaches of the Piedra River. Retaining much of the indigenous Arboles cultural inventory, important cultural elements of the highly developed Chaco Anasazi were added to the resident Arboles lifestyle.

The most heavily Chaco-integrated settlements included more than a hundred sites situated in two Piedra River tributary stream valleys next to a high prominent cuesta just east of the HD Study Area. These sites, consisting of at least seven individual and multiple pueblo structure communities, were clustered to focus on a substantial pueblo, located on a projecting flat-topped "chimney" of the Chimney Rock cuesta. Chimney Rock Pueblo was found to have been built in typical Chaco Anasazi style with two paired, large, masonry Great Kivas incorporated in its architecture. This Chacoan pueblo is now believed to have been part of a network of Chacoan outlier sites scattered throughout and along the periphery of the San Juan Basin. The purpose of such outlier sites, tied together by a vast road system, was probably a combination of direct resource procurement, regional trade, and an extension of the Chaco political and religious system.[10] Although Chimney Rock and the Piedra River Valley were, to some degree, part of the overall Chaco cultural system during this phase, there is, at present, no archaeological evidence of the unifying road system extending to any part of the HD project area.[11]

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[10] Frank Eddy (1977), the chief investigator of Chimney Rock, considers the pueblo to have been established by a group of Chacoan migrant "priest-traders" who organized and influenced the local population to become part of the Chaco system. Eddy sees these Chacoans intermarrying with local Arboles women, helping to strengthen Chaco-Arboles ties. Within a short time, hybrid Arboles-Chacoan settlements were built around the Central Place Chimney Rock Pueblo, tied to it by intermarriage, trade contacts with advanced Chaco Anasazi populations to the south, and the magnet of Chaco religion and ceremony.

[11] Our present knowledge of the Chacoan road system indicates that it linked five major areas of the Chacoan system *except* "the northeast quadrant of the Basin..." which included the Chimney Rock region (See Judge 1989: 243). So far, the apparent lack of Chacoan roads in the Chimney Rock/HD Mountains region has been confirmed by very preliminary examinations of aerial photos and archaeological ground surveys, although an intensive search for their presence has yet to be conducted.

With the exception of the Chimney Rock Pueblo itself, other Chimney Rock habitation sites were little changed from their Arboles antecedents. "Purer" Arboles settlements, further south along the Piedra and San Juan Rivers, continued to function contemporaneously with the immediate Chimney Rock communities up until A.D. 1075. After this point in time, definitive Arboles sites either faded from the scene or had changed their cultural inventory enough to be recognized as part of the Chimney Rock Phase. Environmental deterioration, begun in late Rosa times, continued into the Chimney Rock Phase and, at least in part, encouraged Anasazi abandonment of the HD Mountains region by A.D. 1125.

Aside from the "classic" Chaocan-style Chimney Rock Pueblo, Chimney Rock Phase sites retained numerous Arboles Phase cultural traits. There were, however, some differences. The primary living structure was a surface or immediately sub-surface circular masonry room, really a modified surface version of a pithouse. Rectangular, masonry storeroom blocks formed linear, and occasionally L-shaped, pueblos which enclosed these surface pithouses and sub-surface ceremonial kivas. Site locations were determined, as in times past, largely by proximity to water and arable soils for agriculture.

Chimney Rock material culture was little changed from that of the previous and partly contemporaneous Arboles Phase. Ceramics remained essentially Arboles types with some modest Chacoan influence. Imported ceramics were almost entirely Chacoan types, but these were mostly found at the Chimney Rock Pueblo itself.

Nearly all known Chimney Rock Phase sites are located within the Devils and Stollsteimer Creek drainages around Chimney Rock cuesta. One village site in the Spring Creek Archaeological District was identified in a survey report as a Chimney Rock site, but additional work needs to be done to establish its exact phase affiliation.

Pueblo III/Pueblo IV (A.D. 1125-1500) - Elsewhere in the Northern Southwest, Anasazi populations underwent considerable cultural change and development. Aggregate pueblo communities of hundreds of individuals continued to grow and evolve complex social, economic, and religious adaptive systems well into the late 12th Century A.D. However, by A.D. 1200, Anasazi communities throughout the Northern Southwest were in decay. Soon after A.D. 1300, nearly all of the Anasazi from New Mexico's San Juan Basin and Southwest Colorado had either abandoned the region or their agriculture-based Formative lifestyle. Former Anasazi populations either died out, migrated to other areas of the Southwest, or drifted back into an anonymous hunter-gatherer lifestyle in their native territories. Failure to successfully adapt was no doubt

heavily determined by adverse climatic change, but social upheaval and culturally-induced ecological destruction of Anasazi environments probably also were a factor.

The HD project region appears to have been effectively abandoned after A.D. 1125 and remained so throughout the Pueblo III and Pueblo IV periods. There is very limited ceramic and lithic evidence of possible Pueblo IV foraging incursions into the HD area from the Jemez Mountains and the Rio Grande Valley to the southeast.

Post-Formative Proto-Historic/Historic Stage(A.D. 1500-1900)

The Post-Formative Stage encompasses the arrival and establishment of late prehistoric and historically documented Native American groups, early Spanish explorers and settlers, and European-American ranchers, farmers, miners and loggers.

Athabascan-Shoshonean Period (A.D. 1300-1550) - This period is a largely hypothetical prehistoric occupation of the HD Region by presumed ancestors of the later Navajo (Athabascan) and Ute (Shoshonean) tribes who later lived in the area. It is hypothesized that ancestral groups of these tribes *may* have moved into the region shortly after its abandonment by Anasazi Pueblo II populations. If this hypothetical occupation did indeed exist, it would have been represented by mainly nomadic hunter-gatherers who left little archaeologically-diagnostic evidence of their presence. A number of ephemeral campsites, lithic scatters, and medium to small, triangular, side-notched projectile points from the HD project area could conceivably belong to this period.

Navajo Tradition (A.D. 1550-1775) - Early, historically documented Navajo occupation of the northern Southwest dates roughly to the mid-Fifteenth Century. While the presence of historic Navajo ancestors in the region is probable prior to this time, good archaeological evidence for them, as noted above, is lacking. At present, two archaeological phases are identified for the Navajo Tradition of the HD Project region: Dinetah and Gobernador.

Dinetah Phase (A.D. 1550-1700) - The Dinetah Phase is poorly known, but is thought to include such cultural traits as forked stick hogans, sweat lodges, biconical, pointed-base, earthenware pottery (Dinetah Utility), and medium to large, triangular, side-notched projectile points (Eddy 1972: 43; Schaafsma 1963: 57). Dinetah Phase Navajos were primarily hunting-gathering people who

practiced limited corn farming in favorable floodplain locations. They came into increasing contact with Pueblo groups, particularly in the Rio Grande Valley, during the 17th Century. After the Pueblo Revolt of A.D. 1680, many puebloan groups fled their towns, and anticipating Spanish revenge, joined and intermarried with Navajo bands in Northern New Mexico. The resulting strong interchange of Pueblo and Navajo cultures led to the creation of the subsequent Navajo Gobernador Phase after A.D. 1700.

The Dinetah Phase, in part, is difficult to define archaeologically for two reasons: (1) its low cultural material visibility during its early developmental stage, and (2) its fairly gradual transition into a *hybridized* Pueblo-Navajo Gobernador Phase. The utility of Dinetah as a distinctive cultural phase is often questioned by archaeologists, but it certainly existed as an early stage of Navajo Tradition development in the northern Southwest.[12]

Gobernador Phase(A.D. 1700-1775) - The Gobernador Phase was a blending of earlier Dinetah and historic Pueblo V culture traits. Important diagnostic features are polychrome rock art, polychrome ceramics, trade pottery from the Rio Grande Valley, and masonry architecture (Eddy 1972: 43; Carlson 1965: 105). Gobernador living sites range from single forked-stick hogans to multiple-unit and village site settlements. Village sites, as an instance, are defined as having three to five masonry single-room houses and accompanying hearths and pit ovens. In the Gobernador Phase, Navajos had a mixed subsistence economy of limited farming, wild food foraging, and sheep-goat pastoralism. Settlement patterns from the phase suggest a transhumant lifestyle of seasonal nomadism with sedentary wintering at home-base homesteads, multiple-house clusters, and small villages.

Navajo occupation of the HD Study Area appears to have been fairly modest in both the Dinetah and Gobernador phases. Navajo Reservoir Project surveys have documented dozens of Navajo sites in the lower Pine, Piedra and San Juan rivers below and just above the Colorado-New Mexico border. But only a handful of Gobernador sites, all short-term camps, are known from the actual HD Study Area. To date, these have been mostly defined by the presence of Navajo Polychrome and Pueblo V Rio Grande Red Wares. Archaeological and historic data indicate that by the late 1700's, even an ephemeral Navajo presence in the HD Study Area was terminated by warfare with resident Utes.

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12 For concerns about its archaeological usefulness, see Carlson 1965: 98; and Eddy 1966: 507.

Historic Ute Tradition(A.D. 1600-Present) - Sometime in the fourteenth century A.D., Native American groups, known historically as Utes, appear to have migrated out of present-day Utah and the Great Basin into Colorado. However, the date of their appearance in the HD Study Area is problematical. The first historically documented mention of Southwest Colorado Utes is a Ute-Spanish treaty made in 1626. Certainly, by A.D. 1800, Southwestern Colorado Ute bands were making their presence felt in pressuring Gobernador Phase Navajo populations away from the present-day Colorado-New Mexico border.

Recognition of historic Ute sites is often difficult and inconclusive. Except for rare pottery, Ute sites are essentially similar to those left by any number of mobile hunting-gathering peoples over the past several thousand years. Ute site types include various lithic scatters, culturally scarred trees, rock-shelter camps, open camps, and stone ring campsites.[13] Diagnostic ceramics, when present, consist of a micaceous brownware, sometimes called Uncompahgre Brown (See Hill and Kane 1988; Reed 1988). The occasional presence of Jeddito Yellowware pottery from the Hopi pueblos in Northeastern Arizona is often considered an indicator of Ute-Hopi trade (Hill and Kane 1988: 64). Lithic tools at Ute sites are generally non-diagnostic although small, triangular, side-notched and un-notched projectile points are a reasonably good Ute culture indicator in the HD Project region.

While Utes consistently occupied the HD Study Area from at least A.D. 1600, definitive archaeological evidence for their presence is rare. An extensive survey and culture resource overview for the HDs, published in 1985, located a number of culturally-scarred trees thought to have been Ute in origin. To date, Ute brownware has not been reported, but Jeddito Yellowwares from the Spring Creek drainage were most likely Ute trade items. In addition, at least one stone circle site campsite has been identified as a probable Ute site.

Spanish-American Tradition (A.D. 1600-Present) - The first official record of the Spanish in the project area vicinity was the Rivera Expedition of the 1760s. In 1776, the Dominguez-Escalante expedition trailed into the region. Records from that expedition showed that it traveled along the Navajo River and crossed the San Juan River near the modern town of Carracas, Colorado. There is also evidence that the expedition

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[13] Scarred trees are particularly interesting indicators of a Ute presence in the HD region. Trees, including Ponderosa Pine and Aspens, were partially stripped of their lower bark. The bark was then used for medicines and a number of economic purposes (See Cole 1988; Martorano 1988; and Martorano et al. 1985).

passed near present-day Ignacio, Colorado, and crossed the Florida River on its way toward today's Durango, Colorado (Warner and Chavez 1976: 9-11). It is probable that the Spanish were present in the HD Mountains area prior to the Rivera and Dominguez-Escalante expeditions. Both unofficial and undocumented mining activities were not unusual in the early Spanish Southwest. In fact, such activities have been suggested as having taken place in the La Plata mountains to the west and physical evidence of Spanish mines are known as far north as Fairplay, Colorado (Duane Smith, Fort Lewis College, 1988, personal communication).

Aside from early Spanish mining, a local Spanish-American presence might be found in the form of early homesteads, rancheros, and herding camps. These would have been an extension of New Mexico's early Spanish-American Tradition. The Spanish-American Tradition originated with the establishment of a Spanish colony at San Juan Pueblo in A.D. 1598. It was a blend of Spanish and Puebloan customs with a dominant Spanish theme. Important cultural traits include Puebloan building techniques, farming methods, and cooking, along with Spanish language, the Catholic religion, political organization, domestic livestock production, and fruit tree farming. A late regional phase for the tradition, the Lucero Phase (A.D. 1870-Present), was established by Navajo Reservoir Project research. Culturally, the Lucero Phase is represented by a settlement network of farm homesteads, sheep camps, and small towns.

There is no direct documentation of Spanish-American Tradition sites within the HD Project boundaries. Spanish-American homesteads, however, are located in the Piedra River Valley, immediately to the east. Some exploitation of the HD Study Area, though, is likely to have occurred in the past, particularly in the nature of sheep grazing.

European-American Tradition (A.D. 1848-Present) - The European-American Tradition started in the Southwest with the end of the Mexican-American War and the signing of the Treaty of Guadalupe-Hidalgo in 1848. At that time, a vast region from Texas to the Pacific Ocean and from the Rio Grande River to the 42nd Parallel was incorporated into the United States (Ubbelohde et al. 1972: 49). The first locally important act of the U.S. Government was an official treaty with the Ute Indians, signed at Albuquerque, New Mexico, in 1849. This first U.S.-Ute treaty restricted the Utes to their established traditional territory, roughly the western two-thirds of the present state of Colorado (O'Rourke 1980: 47).

Nine years later, in 1858, a major influx of European-American population into the Colorado Territory began with the discovery of gold at Cherry Creek near Denver. However, the gold rush was not an eastern slope phenomena and Southwest Colorado was soon being settled due, in part, to the discovery of precious

minerals in the San Juan Mountains and at Baker's Park north of Durango. In 1873, the Brunot Treaty (*aka* the San Juan Secession) was signed to ensure European-American access to mining areas on Ute treaty lands. By that treaty, the Utes agreed to give up some four million acres in the San Juan Mountains (O'Rourke 1980: 52-71). Subsequent events, however, undermined the objectives of the treaty. Ignoring its provisions, miners and mining companies expanded well beyond the "seceded" lands deep into Ute territory. As part of that expansion, the town of Durango was staked in 1880, followed by the town of Bayfield to the east in 1886 (Eichler 1977: 10, 25). In 1881, the railroad arrived at Durango and made it a prosperous shipping center as well as a mining town. With the railroad came ever more miners, then ranchers and farmers.

Mining was an important business in the San Juan and La Plata mountains and its activities were largely confined to those areas although some mining took place in the general HD vicinity. This is shown by a Colorado Bureau of Mines listing, which notes that $1,592 of gold and $302 in silver were recovered from Archeuleta County between 1887 and 1904 (Scott 1932: 30). Accordingly, it is probable that prospecting pits may be encountered throughout the HD project area even though few have yet been recorded. The exception is site AR-02-13-08-72 (San Juan National Forest site number). It is located between Green and Zabel Canyons in the Spring Creek Archaeological District and has been identified as being either "Nigger John's Hole/Gold Mine" or "Charlie White's Hole". The site was created by either by mineral prospecting or searching for a lost Spanish Mine (San Juan National Forest Cultural Resource Records).

With the building of the railroads also came the logging industry due to the need for ties, railroad cars, and housing for construction and railroad workers. At the beginning, logging activities were mainly confined to satisfying railroad construction needs. Later, the logging business expanded as lumber demand increased with better transportation and expanded access to new, more distant markets. New logging companies, legally separate from the regionally-operating railroads, were formed, but continued working closely with those railroads. As these "new" partnerships came into being, many more railroad lines and spurs were built into new and old logging areas in the region. The main railroad companies operating in the HD project region were the Denver & Rio Grande, the Rio Grande & Pagosa Springs, and the Rio Grande, Pagosa & Northern (Chappell 1971: 27, 30, 34-39). Primary logging in the region was accomplished by the Pagosa Lumber Company. From around 1895 to 1918, this combination of railroading and lumbering was a prosperous enterprise (Chappell 1971: 27-42, 76-77).

As a rule, the HD project area was not heavily affected by early commercial logging activities. These were mainly confined to the east of Stollsteimer Creek and north of present-day U.S. Highway 160 (Chappell 1971: 38). Major logging and milling settlements, located immediately outside the project area, were Dyke, Altura, Lonetree, Kerns, and the town of Pagosa Junction. However, there are a number of local, very small-scale lumber/sawmilling localities within the project area, particularly on the western, Pine River side of the HD Mountains. These are the residue of lumber processing sites for local ranches and farm homesteads. Many are on the sites of, or adjacent to, pioneer homesteads and ranches.

In addition to encouraging commercial lumbering operations, the growth of railroads in the region also assisted the growth of regional ranching. The first European-American ranches were established in the early 1870s. Initially, these ranches tended to be quite large due to the availability of vast open rangelands. Eventually, with growing populations and the advent of homesteading and farming, these large ranches were gradually broken up. By 1895, with the enactment of the Hunter Act, large ranches were mainly a feature of the past. The Hunter Act broke up the previously existing Southern Ute Reservation, granted lands parcels to the Utes, and opened the remaining lands to homesteading. Break-up of the former reservation lands significantly reduced the area of open range previously used by earlier, large cattle ranches (O'Rourke 1980: 81-82).

The HD project area once included a number of large ranches, but the most important was the HD Ranch, from which the area takes its name. In 1876, Ben Pargin, through a trade, acquired the HD Ranch along with a cabin east of Bayfield (Motter 1984: 219). By 1879 or 1880, the ranch came into the possession of Sam Parks when two men, Weaver and Baker, moved in some eight hundred head of cattle. Forming a cattle company, the three men used the HD Ranch as headquarters and adopted the "HD" brand. Cattle from the ranch ranged throughout the HD Mountains, including a winter pasture in Spring Creek (Zabel Canyon), the lower foothills of the Pine and Piedra rivers, and Ute Reservation lands to the south (Scott 1932: 75). The ranch was sold shortly after the enactment of the Hunter Act in 1895 (Scott 1932: 75). Cultural remains of line shacks related to ranching are certainly present in the project area as well as abandoned homesteads on former Ute lands.

In 1905, the U.S. Congress granted some 85.6 million acres nationwide to the Bureau of Forestry, and firmly established the U.S. Forest Service. By 1907, national forest lands reached 194.5 million acres, mostly in western states (Robinson 1975: 8-9). In that short time span, substantial portions of the HD Mountains and the Spring Creek drainage was incorporated as NFS lands. Timbering of the project area, under Forest

Service direction, has continued to the present day, and evidence of more recently logging operations should be apparent, particularly along the more easily accessible drainage bottomlands.

During the early decades of the 20th Century, a number of small farms and ranches were established in the project area, mostly on the western side of the HD Mountains. Much of that land remains in private hands today.

Only small numbers of historic through recent modern European-American sites have been recorded for the HD Study Area. These include such site types as abandoned logging camps, abandoned farm and ranch homesteads, a privy, and various trash dumps.

DISTRIBUTION AND COMPOSITION OF HD MOUNTAINS CULTURAL RESOURCES

Analysis of the HD Mountains cultural resources is complicated by the uneven quality of site and survey reports available for the area. The most rigorous study of cultural resources in the HD region is contained in Cultural Resources Survey of the Durango Known Recoverable Coal Resource Area by Martorano et al. (1985). In that study, Martorano et al. thoroughly analyzed a large number of lithic and ceramic artifacts to determine their mostly likely cultural affiliation based on known technical data. The overall implications of the study was, particularly, to orient Archaic and Formative Stage period and phase definitions to the

significant cultural database of the Navajo Reservoir Project of the 1950s and 1960s and University of Colorado investigations of the Chimney Rock region in the 1970s.[14] Supporting research for the Martorano et al. study came from immediately subsequent University of Northern Colorado fieldwork in the Crowbar Creek drainage of the Pine River Valley (Brunswig 1986).

Cultural definitions given in the following tables reflect a site by site assessment of the field data for the HD Study Area and follow period and phase criteria set down in the preceding cultural framework section.

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[14] Unfortunately, until the publication of the Mortorano et al. study, and in some cases, since, cultural identifications of these two stages, particularly the Formative Stage, have tended to follow largely non-rigorous and normative definitions of site cultural affiliation based from experience with assemblages outside the project area. When faced with limited field-based, survey conditions, cultural identification of periods and phases defined through extra-regional, comparative judgments is understandable. It is particularly understandable where field surveyors are versed in artifacts, particularly ceramic types, from Mesa Verde or the Las Animas Valley to the west and have little acquaintance with the often quite different traits of the Navajo Reservoir phases. A particular problem, in this regard, has been the common identification of pithouse sites with abundant plain graywares, often identified as Chapin Gray, as Basketmaker III. The Basketmaker III/Navajo Reservoir Sambrito Phase is defined by the presence of Sambrito Brownware and very rare graywares, all in the form of imported Chapin Gray ceramics. For instance, both the Mortorano et al. ceramic analyses and field checking by this author of earlier Basketmaker III-defined sites the Crowbar and Saul's Creek area indicate that pithouse sites with abundant grayware fit into the Pueblo I, Rosa Phase, definition. Accordingly, field data for all Anasazi habitation sites was examined in as great a detail as possible and some sites were redefined for period and phase in accordance with Navajo Reservoir phase trait criteria. Similarly, where possible, projectile point data were examined and cultural provenance were assigned based on currently available trait definitions. Sources for this report's period/phase lithic and ceramic technical definitions include: Breternitz, Rohn and Morris 1974; Dittert, Eddy and Dickey 1963; Dittert, Hester and Eddy 1961; Dittert and Eddy 1963; Eddy 1961; 1966; 1977; Irwin-Williams 1973; and Martorano et al. 1985.

Cultural/Chronological Distributions of HD Mountains Sites

Some 448 archaeological sites of all types were catalogued from the HD Study Area. Of that number, 324 sites qualified as significant archaeological resources.[15] The remaining 124 sites were isolated finds of roughly ten non-diagnostic artifacts or less. As shown in the following table, of 324 primary archaeological sites in the HD Study Area, more than half, 60.5 percent, belonged to the Anasazi Tradition of the Formative Stage. More than 23 percent were sites with unknown cultural provenance. Historic Ute sites came to 6.0 percent of the total, and 4.0 percent were of Historic Euro-American origin. Archaic sites made up 3.4 percent and Gobernador Navajo sites constituted 1.8 percent of the overall cultural resource inventory. One questionable Paleo-Indian find made up the remaining 00.3 percent of documented HD sites. See Table C-8-2.

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[15] Archaeological site data for the project database were analyzed with the use of several site type classes. These ranged from isolated artifact finds to major multi-component sites with extensive structural remains. For the purpose of this study, an archaeological site is broadly defined as "any locality with past evidence of human activity." Within this definition, are two overlying categories of sites: (1) isolated, non-diagnostic cultural resources and, (2) significant, diagnostic cultural resources.

Isolated cultural resources include isolated finds and small archaeological resources (cf. Martorano et al. 1985: 57-58). Isolated finds (IF) are singular human-modified or human-manufactured objects without demonstrable association with other artifacts or structural remains belonging to past human activity and having *no* datable or culturally-diagnostic traits. Small archaeological resources (SAR) are concentrations, or light scatters, of human-made or modified objects without demonstrable association with other artifactual or structural remains or evidence of human activity and having *no* datable or culturally-diagnostic traits.

Significant diagnostic cultural resource sites are concentrations of light to heavy scatters of artifacts and/or structures with datable, culturally-diagnostic traits. This site category ranges from such site types as lithic processing floors, plant and animal activity areas, short-term and long-term camps, habitation sites ranging from single living structures to multiple structure "community" sites, historic logging camps, historic farmsteads, etc. This category includes, but is not restricted solely to, sites on or eligible for nomination to the National Register of Historic Places.

TABLE C-8-2

HD ARCHAEOLOGICAL COMPONENTS BY CULTURAL PROVENANCE

Stage/Period of Occupation	Number*	% of Total
Unknown Cultural Affiliation	77	23.8%
Paleo-Indian Stage	1	00.3%
Archaic Stage	11	03.4%
Formative Stage/Anasazi	196	60.5%
Navajo Tradition/Gobernador Phase	6	01.8%
Historic Ute Tradition	20	06.2%
European-American	13	04.0%
TOTAL	324	100.0%

*This listing includes a number of multi-component sites.

A further break-down in cultural affiliation into local periods and phases documents important, if still premature, trends in HD Mountains culture history. Table C-8-3 shows that Middle Archaic sites, largely of the Oshara Tradition's San Jose Phase, represent nearly all Archaic Stage sites: nine of eleven. Definitive Basketmaker III sites, based on Navajo Reservoir phase-dating criteria, are restricted to one campsite. This finding is in line with a recent HD region Cultural Resource overview conclusion that Pine and Piedra River Basketmaker III sites were confined to their lower reaches, south of the HD Study Area (Eddy, Kane and Nickens 1984: 76-93). Basketmaker II sites are also rare, numbering a total of seven, including two campsites, two isolated projectile point finds, a lithic scatter, and two possibly "curated" Basketmaker II points found on Rosa Phase habitation sites. The lack of Basketmaker II sites is more puzzling than the absence of Basketmaker III sites since they are thought to be extensively located along the adjacent mid- and upper-Pine River environs.

Site analysis of HD Mountains data indicates that Anasazi Tradition sites are almost exclusively Pueblo I in composition, most belonging to the Navajo Reservoir's Early Pueblo I Rosa Phase. A few of the Rosa Phase sites, according to the Mortorano et al. study, also included rare Piedra Phase ceramics, but it not known whether this meant they were occupied in the Late Pueblo I Piedra Phase or the ceramics represent random revisits of previously abandoned sites. The vast majority of Pueblo I sites, seventy-eight in all, are habitation localities. Fifty-seven Pueblo I sites are scattered single-unit homesteads consisting of

pitstructures and accompanying jacal surface rooms. Fourteen Pueblo I sites are multiple-unit localities and at least two appear to qualify as villages. The remaining fifty-four sites of Pueblo I date are lithic quarries, various activity campsites, and lithic and ceramic scatters, all representative of habitation site economic activity support functions. Pueblo II sites include seventeen probable Arboles Phase localities and one Chimney Rock Phase locality. All of the Arboles Phase components are either campsites, lithic and ceramic scatters, or inclusive, as minor elements, in habitation sites also dating to the Pueblo I period. The one identified Chimney Rock "Village" stands isolated and alone among dozens of Pueblo I settlements in the Spring Creek Archaeological District. Considering that Chimney Rock Phase sites have previously been thought to be largely confined to the Chimney Rock Archaeological District, the Spring Creek site needs to be more adequately investigated.

HD Project Navajo sites are rare and, as noted in the cultural framework section, appear to represent ephemeral resource exploitation of the HD Study Area. Historic Ute sites, even with their difficulty of diagnosis, are fairly well-represented and support the historic record of Ute occupation since at least the early 19th Century. European-American localities are fairly rare or poorly recorded and represent logging, ranching, and farming activities historically documented for the area.

TABLE C-8-3

CULTURAL AFFILIATION BY KNOWN PERIODS AND PHASES

Cultural Period/Phase	Number of Sites/Components
Paleo-Indian	1
Middle Archaic	9
Late Archaic	2
Basketmaker II/Los Pinos Phase	7
Basketmaker III/Sambrito Phase	1
Early Pueblo I/Rosa Phase	109
Late Pueblo I/Piedra Phase	26
Early Pueblo II/Arboles Phase	18
Late Pueblo II/Chimney Rock Phase	1
Undefined Pueblo I/Pueblo II	34
Navajo Tradition/Gobernador Phase	6
Historic Ute Tradition	20
Historic European-American	13
TOTAL	247

In physiographic terms, the HD Study Area is divided into the eastern and western slopes of the HD Mountains. Topographic conditions, including important environmental factors conducive to human economic exploitation, vary somewhat between the two sections. Eastern slope topography is somewhat broken and rugged with narrow tributary drainages of the Piedra River confined by high mountainous terrain and steep mesitas and cuestas. For human populations, this type of topography limits arable land needed for agriculture and restricts conditions for dense plant and animal food bio-mass for hunting and gathering activities. The ruggedness of the eastern HDs is partly due to the fact that distances from the HD Mountains divide to the Piedra River are shorter and gradients are much steeper than in the Pine River Valley west of the divide. Immediately east and bordering the HD Study Area, topographic relief of the Piedra River floodplain and confluence areas of its western tributary streams is fairly abrupt and limited in terms of modest slope and deep soil areas. The only area of the eastern HDs which have moderate relief are a group of small, relatively flat drainages in the southeastern corner of the HD Study Area. These drainages include the Skull Canyon, Goose Creek, Turkey Creek and Ignacio Creek valleys. In contrast, the

western slope section contains stream drainages with low gradients and extended sedimentary floodplain formation through most of their lengths. In most cases, the highest gradients and elevation gains are found in the upper one to two miles of the Pine River tributaries.

Within the eastern HD foothills and the adjacent Pine River floodplain, human economic potential is high in terms of arable soils, less destructive water runoff, and overall plant and animal bio-mass densities. With these facts in mind, it can be said that eastern slope of the HD Mountains, within the HD Study Area present less potential for human economic resource exploitation, particularly for agriculturalists, than the western slope section. Supporting this thesis is the current cultural resource database which indicates that the eastern HDs have been less intensely exploited by past human populations than the western HDs. Table C-8-4 documents this disparity for nearly every cultural period and phase except for the Pueblo I/Piedra Phase and the Pueblo II/Arboles Phase. Further, this apparent disparity in site density fits in well with current Anasazi culture history reconstructions which see the Pine Valley being virtually abandoned by the Piedra Phase and Piedra/Arboles populations colonizing upstream along the Piedra River from the Navajo Reservoir District. However, it should also be pointed out that a potential "skew" factor exists between the two slopes sections. Survey data for the HD's are not nearly so complete and rigorous as for the western HD section.

Site data for the project area indicates that the heaviest site densities are found in the mid to lower sections of the Spring Creek, Ute Creek, Crowbar Creek, and Saul's Creek drainages of the western HD slope area. As expected, the very heaviest known site concentrations are found in the Spring Archaeological District followed by Crowbar Creek and Armstrong Canyon. Lesser, but still significant, site densities are found in the Turkey, Goose, Skull Canyon and Ignacio Creek drainages in the southeast corner of the HD Study Area.

TABLE C-8-4

COMPARATIVE CULTURAL RESOURCE DISTRIBUTIONS IN THE WESTERN AND EASTERN SLOPE HD MOUNTAINS SECTIONS

Period/Phase	Western Slope	Eastern Slope
Paleo-Indian	0	1
Middle Archaic	7	2
Late Archaic	2	0
Basketmaker II/Los Pinos Phase	6	1
Basketmaker III/Sambrito Phase	1	0
Pueblo I/Rosa Phase	98	11
Pueblo I/Piedra Phase	13	13
Pueblo II/Arboles Phase	7	11
Pueblo II/Chimney Rock Phase	1	0
Non-Definitive Pueblo I-II	22	12
Navajo/Gobernador Phase	4	2
Historic Ute	7	3
European-American	10	3
Unknown Provenance	59	18
TOTALS	247	77

Site Distributions and Topographic Environments

Analysis of site topographic data for the project area is hampered by a general paucity of good, detailed, environmental description from both site and survey report sources. Despite this constraint, an effort was made to tabulate generalized topographic data for as many significant archaeological sites as possible. These were entered in the computer database and are shown tabulated in Table C-8-5 below. In the table, primary site types are correlated with five very basic categories of topographic features: (1) ridge and mesatops, (2) benches situated on ridge slopes, (3) gentle ridge slopes, often expressed as eroded secondary colluviated terraces or alluvial fans, (4) primary stream terraces, at or immediately above the modern floodplains, and (5) secondary terraces, largely intact low gradient terrace features dating from the Late Pleistocene through the mid Holocene. As might be expected, site topographic correlations in Table C-8-5 stress the importance of water proximity, arable, well-drained soils, modest slope gradients, and high, secure vistas for most site

locations. The exact combination of topographic factors utilized in choosing any site, however, depends on its basic cultural function and any number of localized micro-environmental factors. There are, however, some broad generalizations which can be made from the data.

TABLE C-8-5

TOPOGRAPHIC LOCATIONS FOR HD SITE TYPES*

Site Type	Topographic Environment				
	Ridge/Mesa Top	Ridge Bench	Gentle Ridge Slope	Primary Terrace	Secondary Terrace
Lithic Scatter	7	1	11	5	11
Quarry/Workshop	4	1	1	0	0
Lithic/Ceramic Scatter	7	-	1	2	2
Ceramic Scatter	-	-	-	-	2
Campsite/Special Activity	43	3	7	16	28
Stone Circles	-	-	-	-	1
Single Habitation Units	29	9	1	4	6
Multiple Habitation Units	5	1	-	2	2
Village Habitation Units	5	-	-	-	1
Historic Logging Camp	1	-	-	1	-
Historic Homestead	-	1	1	2	2
Historic Trash Dump	-	1	-	-	-

*This includes all sites for which topographic environment data could be obtained above.

Lithic scatters, lithic quarry/workshops, ceramic scatters, and architectural habitation sites all have a pronounced tendency to be located on ridge and mesa tops. However, campsites, usually representing wild plant and animal food foraging and processing activities, are just as apt to be situated on primary and secondary stream terraces as on ridge or mesa tops. And, given a particular set of micro-environmental conditions, some site types, such as the Anasazi habitation units, can be located on ridge benches and primary or secondary stream terraces.

APPENDIX D
BIOLOGICAL ASSESSMENT FOR THE EXPANSION OF
EXTRACTION FACILITIES IN THE HD MOUNTAINS

APPENDIX D

BIOLOGICAL ASSESSMENT
FOR THE
EXPANSION OF GAS EXTRACTION FACILITIES
IN THE
HD MOUNTAINS
LA PLATA AND ARCHULETA COUNTIES, COLORADO

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to

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May 3, 1990

APPENDIX D - BIOLOGICAL ASSESSMENT

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HD MOUNTAINS BIOLOGICAL ASSESSMENT

1.0 INTRODUCTION

Amoco Production Company proposes to expand development of coalbed methane gas extraction facilities in the HD Mountains. The U.S. Forest Service (USFS), as the lead federal agency, is preparing an Environmental Impact Statement (EIS) to evaluate the effects of different development alternatives. To comply with section 7(c) of the Endangered Species Act of 1973 (ESA), as amended, the USFS, as defined in the National Environmental Protection Act (NEPA), is required to obtain information from the U.S. Fish and Wildlife Service (USFWS) on any threatened or endangered species or critical habitat which may be present in the area of the proposed project. Furthermore, the USFS must submit to the USFWS a biological assessment that determines the effects of the project on the listed species.

Potential impacts of the proposed gas field expansion on federal and state threatened, endangered, and candidate plant and animal species that may exist in the project's area of influence are discussed in this assessment. The following species are addressed:

1. Bald eagle (Haliaeetus leucocephalus): federal and state endangered species.
2. Peregrine falcon (Falco peregrinus anatum): federal and state endangered species.
3. Black-footed ferret (Mustela nigripes): federal and state endangered species.
4. Colorado squawfish (Ptychocheilus lucius): federal and state endangered species.
5. Ferruginous hawk (Buteo regalis): federal candidate species.
6. White-faced ibis (Plegadis chihi): federal candidate species.
7. Long-billed curlew (Numenius americanus): federal candidate species.
8. Mexican spotted owl (Strix occidentalis lucida): sub-species being reviewed for federal listing as threatened or endangered. However the lucida subspecies, at present, has no legal status under the ESA (USFWS 1990).
9. North American wolverine (Gulo gulo luscus): federal candidate species.
10. River otter (Lutra canadensis): Colorado endangered species.
11. Roundtail chub (Gila robusta): federal notice of review and New Mexico endangered species.
12. Bonytail (Gila elegans): Colorado endangered species.

2.0 STUDY AREA

The study area is located in southwestern Colorado approximately 21 miles east of Durango. The study area, containing all proposed gas-related facilities, is bounded on the north by U.S. Highway 160, on the east by Colorado Highway 151, on the south by the Southern Ute Indian Reservation, and on the west by La Plata County Road 521. This area contains 56,910 acres (88.8 square miles), 79.2 of which is on USFS lands. The remaining lands are privately- or state-owned.

3.0 DESCRIPTION OF PROJECT AND ALTERNATIVES

Under the No Action Alternative (Alternative A), the only additional gas development activities that would be installed would be 25.5 miles of flowlines in the Fosset Gulch Road-Pargin Mountain, Spring Creek, Sauls Creek-Lange Canyon, Spring Creek-Reservoir Canyon, and upper Crowbar Creek areas. The 20-foot-wide flowline right-of-ways (ROW) would be constructed mostly adjacent to existing roads between July 15, and November 15, outside the period of big game winter range occupancy. Operational activities associated with 21 existing wells (45 acres) on USFS lands and 22 existing wells (66 acres) on private lands would continue in the study area under the No Action Alternative. Wells on USFS and private lands are accessed by 33 and 23 miles (80 and 56 acres) of existing USFS and well access roads, respectively. Past and current gas development activities have affected most wildlife groups in the study area to varying degrees. Most impacts have been relatively minor.

Under the Proposed Action Alternative (Alternative B), 34 additional gas wells (102 acres) would be developed in the study area, 28 (84 acres) on USFS lands and 6 (18 acres) off USFS lands. Sixteen wells would be located in the area southeast of Pargin Mountain, 5 in Sauls Creek, 5 in Spring Creek, and 8 in Armstrong and Ritter Canyons. This would result in the operation of 77 wells in the study area, 49 on USFS lands and 28 off USFS lands. New access roads/flowlines would total 23 miles (144 acres) and just flowlines would total 19 miles (46 acres) on USFS lands and 4.5 miles (27 acres) and 6.5 miles (16 acres) off USFS lands, respectively. Road construction and well development would be largely completed in 1991. One compressor station would be installed on USFS lands.

Under the Current Direction Alternative (Alternative C), 116 additional gas wells (348 acres) would be developed in the study area over 7 years, 95 (285 acres) on USFS lands and 21 (63 acres) on private lands. New wells would be accessed by 73 miles (439 acres) of new road and 116 miles (223 acres) of existing roads. In relation to Alternative B, one additional compressor station would be installed on private lands. Total additional acreage of direct disturbance would be 849 acres, 646 acres of which would be on USFS lands. Indirect disturbance to wildlife and their habitats would result from the operation of 161 wells, 116 of which would be on USFS lands. Gas development under this alternative would represent full development under State spacing requirements on USFS lands within the study area, with the exception of the highest elevations in the HD Mountains which, at present, are economically impractical to develop. This means that, excluding the above area, every square mile of USFS lands in the study area will contain 2 wells and ancillary facilities. Gas development on private and state lands under Alternative C would also represent maximum development under state requirements.

4.0 METHODS

On behalf of the U.S. Forest Service, Western Ecosystems, Inc. solicited information from the USFWS on any threatened, endangered, or candidate species or critical habitats, etc. that may be affected by the project. In a responding letter, dated June 28, 1989, the USFWS indicated the following listed and candidate species may occur within the project's area of influence:

- Colorado squawfish (federal endangered)
- Bald eagle (federal endangered)
- Peregrine falcon (federal endangered)
- Black-footed ferret (federal endangered)
- White-faced ibis (federal candidate)
- Long-billed curlew (federal candidate)
- Ferruginous hawk (federal candidate)
- North American wolverine (federal candidate)

The roundtail chub, bonytail, and river otter will also be considered in this assessment to meet requirements of the Colorado and New Mexico Endangered Species Acts. In addition, the Mexican spotted owl will be addressed herein, because of recent evidence that it occurs close to the project area (Reynolds 1989, pers. comm.) and because the USFWS has recently initiated a status review on the subspecies.

This assessment is based primarily on existing information obtained from the USFS, USFWS, Bureau of Land Management (BLM), Colorado Division of Wildlife (CDOW), New Mexico Game and Fish Department (NMGF), and other biologists. Field (reconnaissance) surveys were conducted in the area on June 26-28, 1989.

The CDOW supplied Wildlife Resource Information System (WRIS) maps, updated in June 1989, delineating the seasonal ranges of bald eagles, peregrine falcons, river otters, and other nonthreatened and nonendangered wildlife resources in and proximal to the study area. These seasonal polygons were digitized for transcription into a Geographic Information System (GIS) by Woodward-Clyde Consultants. Vegetation types in the study area were mapped by Jeff Dawson (Woodward-Clyde) and incorporated into the GIS system. This system was used to (1) avoid ecologically sensitive areas (and other areas imposing

development constraints) when siting potential wells and road/flowline right-of-ways (ROWs) and (2) to quantify the acreage of habitats and seasonal polygons affected by the proposed facilities.

5.0 HABITATS PRESENT

The study area covers 56,910 acres, extends from approximately 6,300 feet along the Piedra River to 8,936 feet at Pargin Mountain, and includes the northern two-thirds of the HD Mountains. Aquatic habitats present include the Piedra River, a moderately-sized tributary of the San Juan and Colorado Rivers that empties into Navajo Reservoir, portions of Beaver, Hayden, Squaw, and Yellowjacket Creeks (all perennial), and a number of intermittent creeks that are tributaries to the Piedra or Los Pinos (Pine) Rivers. The perennial creeks and the Piedra River run along the northern and eastern peripheries of the study area.

Relatively extensive cottonwood stands flank the lower sections of the Piedra River and extend as narrow stringers a short distance up some of the intermittent eastern tributaries. Above the cottonwood riparian zone is a grassland/sagebrush vegetation type that occurs at lower elevations on both east and west slopes of the HD Mountains. This type, in particular, is grazed by domestic cattle. It is most extensive on the western side of the study area where it extends up canyons and forms small parks in the study area's northwest corner. In the study area's southeastern corner, stringers and islands of pinyon pine and juniper are interspersed in the grasslands. Much of the sagebrush and pinyon-juniper types immediately off USFS lands have been cleared on the lower, southeastern study area slopes for irrigated and fertilized agricultural lands primarily oriented toward hay production.

Open and closed ponderosa pine forest occurs above the grassland and pinyon pine types and is the most extensive type in the study area. Ponderosa pine understories are primarily oakbrush, with serviceberry, Woods' rose, and mountain mahogany. Interspersed in this type, at lower to upper elevations, are small to extensive oakbrush stands. Aspen occurs as stringers along some of the intermittent drainages and in a few stands on northern slopes, but this type is not common in the area. Douglas-fir, white fir, Engelmann spruce, and subalpine fir stands are present at upper elevations of the HD Mountains, particularly on north-facing slopes. These species often intergrade, depending on aspect, elevation, and substrate, to the extent that they are most commonly associated in a mixed conifer type.

Upper elevations, and most (79.2 percent) of the study area, occurs in the San Juan National Forest. Private lands occur along the east, north, and west flanks of the study area. The Southern Ute Indian Reservation borders the study area on the south. Land use on private lands is primarily agricultural. Gas well development has occurred throughout the study area, but is most concentrated at lower elevations along the western third and southeastern corner of the study area. Some logging occurs on the Forest and the area is moderately used for recreation, especially during the hunting seasons.

Under the No Action Alternative, 62 acres of wildlife habitats in the study area will be converted to a reclaimed grassland type due to flowline installation. This acreage totals less than 1% of that in the study area and 74 percent of this loss would be on USFS lands.

Implementation of Alternative B will result in long-term changes to 332 acres (0.6 percent) of the study area as a result of facilities installations. Eighty-two percent of this disturbance will be on USFS lands. The largest acreages of individual vegetation types to be converted to well pads, roads, and reclaimed areas include pinyon-juniper, ponderosa pine, oakbrush, and sagebrush. These four types account for 94.4 percent of the acreage that will be directly disturbed.

Implementation of Alternative C will result in long-term changes to 849 acres (1.5 percent) of the study area. The largest acreages of individual vegetation types to be converted to wellpads, roads, and reclaimed areas are ponderosa pine, pinyon-juniper, oakbrush, sagebrush, mixed conifer, and cropland/pasture. Cottonwood/ willow and aspen, high-value wildlife habitats, will be reduced by about 80 and 12 acres, respectively. Eighty-six percent of Alternative C disturbances will be on USFS lands.

6.0 SPECIES OF SPECIAL CONCERN AND DETERMINATION OF EFFECT

Based on available, existing data, the USFWS indicated (letter dated June 28, 1989) that "no species federally proposed or listed as threatened or endangered occur(s) in the project area". However, observations of local biologists and unpublished data indicate that the bald eagle is seasonally present in the area and that species of special concern occur, or may occur, within the project's potential zone of influence. These species are individually addressed below.

6.1 FEDERAL, THREATENED AND ENDANGERED SPECIES

6.1.1 Bald Eagle

Bald eagles are federal and state endangered winter residents in the vicinity of the HD Mountains study area. They are currently being considered for delisting to federal threatened status. CDOW WRIS mapping identified bald eagle winter ranges and winter concentration areas along portions of the Pine and Piedra rivers and some of their tributaries (Figure 3-8). These rivers serve as corridors where eagles move up and down to fish open areas and to hunt waterfowl. These corridors generally include a minimum of one-half mile on each side of the river. The only portion of the study area overlapped by WRIS bald eagle winter range is 703 acres along the eastern periphery, which flanks the Piedra River. There is no overlap between the study area and bald eagle winter concentration areas. Dick Fentzlaff (CDOW, DWM) and John Castellano (BLM, wildlife biologist) have both reported a low number of bald eagles (1-2 birds) opportunistically roosting in the relatively broad cottonwood stands flanking the river in the southeastern part of this area.

No active bald eagle nests are known to be within the project's area of influence (the project area plus a surrounding zone that could also experience the influence of project-related activities). In 1987, a pair nested in a cottonwood near Navajo Reservoir and fledged two young, but they haven't returned and the nest has fallen down (D. Fentzlaff, CDOW, pers. comm.). The closest active nest is located approximately 27 miles to the northwest (G. Craig, CDOW, pers. comm.).

Bald eagle use of the study area is restricted to low numbers of winter residents which hunt the Piedra River and which frequently leave the winter concentration areas along the Pine and Piedra rivers to scavenge big game carrion, road-killed wildlife, and possibly, to hunt lagomorphs (rabbits and hares) on the lower elevation winter ranges of the HD Mountains. Eagle winter range on upland areas has not been delineated

on WRIS maps and has not been quantified for this analysis. Low numbers of individual bald eagles are often observed in Sauls and Spring Creeks during winter (C. Carron, CDOW, pers. comm.).

None of the alternatives should adversely affect bald eagle use of the area. Under the No Action Alternative, only 6.8 acres of WRIS-designated bald eagle winter range will be directly affected by long-term habitat losses within the Fosset Gulch flowline ROW. Construction activities should not affect eagle use because (1) eagles are not present during the July 15 - November 15 construction period, (2) habitat conversion should not reduce prey species, and (3) the cottonwoods that would be removed from the ROW do not represent roost trees because of their proximity to the Fosset Gulch Road. Flowline installation in upland areas of the HD Mountains, not identified on WRIS maps but where eagles frequently hunt during winter, should also not adversely affect eagles because the construction period and eagle occupancy do not overlap and flowline installation is not expected to adversely affect eagle prey. Past gas operations have probably resulted in disturbance to eagles wintering in the vicinity of the HD Mountains study area. This level of impact will probably continue, but not increase, under Alternative A.

Alternative B habitat losses and construction and operational disturbances may result in minor additional disturbance to bald eagles. No habitat within bald eagle winter concentration areas will be directly affected. Indirect effects should not appreciably exceed present levels. Acreage of WRIS eagle winter range directly affected by well windows and ROWs will total 63.3 acres (9.0 percent of the winter range in the study area), all but 1.5 acres of which will occur on private lands.

Acreage of bald eagle winter range that would be directly affected by Alternative C would total 63.5 acres, 9.0 percent of that available within the study area. Approximately 27 percent of this affected winter range (17 acres) is on USFS lands, 7.8 percent of that available based on WRIS mapping. No bald eagle winter concentration areas will be directly affected. Bald eagles feeding on winter-killed ungulates in the study area may experience more disturbance from increased and more widespread operational activities. Availability of winter-killed ungulates may change if gas development activities effect a decline in big game populations; however, this effect would probably be insignificant relative to the influence that severe vs. mild winters have on the availability of carrion. Overall, impacts associated with this alternative will be greater than those resulting from Alternatives A or B, however, these impacts will still be minor and should allow for continued bald eagle use of the study area at current levels.

6.1.2 Peregrine Falcon

The peregrine falcon, a federal and state endangered species, is an active breeder in the vicinity of the HD Mountains study area. Peregrines are currently being considered for delisting in Colorado to federal "threatened" status. An inactive peregrine eyrie exists at Chimney Rock, approximately 2.5 miles east of the study area boundary. This nest site, the first authenticated one in the state (Bailey and Niedrach 1946), has gone unused for the past several years possibly due to the high numbers of great horned owls at the site (D. Cook, USFS; D. Fentzlaff, CDOW, pers. comm.). Among other areas, birds from the site formerly hunted over the Piedra River. CDOW WRIS maps delineated a hunting range around the eyrie which approached the eastern bank of the Piedra River, but did not overlap the HD Mountains study area. The CDOW makes a distinction between peregrine falcon "hunting range," where Chimney Rock birds hunted most of the time, and "overall range," where hunting also occurred, but less frequently. However, based on the excellent hunting opportunities that exist along the river, it is likely that the Chimney Rock peregrines frequently hunted along the river and over that portion of the study area flanking the river. Although peregrines do not presently nest at Chimney Rock, inclusion of the Piedra River within the "hunting range" of the former pair is appropriate from the perspective of maintaining the viability of the Chimney Rock eyrie.

An active peregrine falcon eyrie, north of U.S. Highway 160 along the Piedra River, fledged three birds in 1989. (Most biologists familiar with the situation consider it likely that the falcons that nested at Chimney Rock moved to the Piedra River site.) Although most hunting by these birds probably occurs within three miles of their nest, they could easily fly 12 or more miles downstream to hunt over the portion of the HD Mountains study area which flanks the Piedra River (G. Craig, CDOW raptor biologist, J. Enderson, biology professor, Colorado College; pers. comm.).

Approximately 4,516.8 acres of the eastern periphery of the HD Mountains study area is within the WRIS designated "overall range" of the inactive Chimney Rock eyrie and may be hunted by birds from the active Piedra nest. However, potential nesting sites are limited in the study area. Dave Cook (USFS biologist, pers. comm.) reported that the head of Ignacio Canyon offered possible nesting habitat. Gerry Craig (CDOW raptor biologist, pers. comm.) surveyed the HD Mountains in 1988 and found "no significant nesting cliffs" and concluded the area did not provide "good nesting habitat." Jim Enderson (biology professor, Colorado College, pers. comm.) knew of no peregrine nests or suitable nesting habitat in the HD Mountains.

None of the alternatives should adversely affect the active Piedra River peregrine eyrie, nor should they significantly reduce potential hunting habitat or jeopardize future viability of the inactive Chimney Rock eyrie.

Under the No Action Alternative, flowline installation along the Fosset Gulch Road will convert 5.0 acres of cottonwood/willow habitat into grassland within what was formerly the overall range of the Chimney Rock peregrine falcons. It is possible that this area is presently hunted by the peregrines currently nesting along the Piedra River north of U.S. Highway 160. However, this habitat conversion should not significantly reduce prey species or hunting opportunities, since peregrines hunt above the canopy. There should be no additional disturbances associated with operational activities under this alternative.

Under the Proposed Action Alternative, 176.6 acres of the overall range of the inactive Chimney Rock eyrie will be altered by ROW and gas well development. This amounts to 3.9 percent of the overall range occurring with the study area. Most (100.3 acres) of this habitat loss will occur on USFS lands; however, the proportion of the peregrine's overall range within the study area represents a small fraction of the overall range extending beyond the study area boundary. At most, this long-term habitat loss should result in only minimally reduced hunting opportunities if the Chimney Rock eyrie is reoccupied. The reduced availability of prey supported and produced in these 177 acres of habitats may be slightly offset by the greater vulnerability of prey crossing openings cleared for well pads; however, these negative and positive effects are probably insignificant. No habitats within the WRIS-designated hunting territory of the Chimney Rock eyrie will be directly affected by gas activities. Indirect impacts to ranges associated with the Chimney Rock eyrie should not appreciably exceed present levels. The effect of direct and indirect gas-related disturbance on the Piedra River peregrines should also be minor, because the eyrie is well buffered from the study area, and because long-term habitat losses will be small relative to the presumed size of the peregrine's hunting territory.

Potential impacts associated with Alternative C gas development will be greater than those resulting from implementation of Alternatives A or B. Under Alternative 3, 362 acres of habitats within the overall range of the inactive Chimney Rock eyrie will be altered by gas development activities for the life of the project. This represents 8 percent of the overall range available (4,517 acres) within the study area, but a fraction of 1 percent of the WRIS designated overall range available beyond the study area. No habitats within the WRIS-designated hunting territory of this former pair would be affected by this alternative. These habitat

losses and minimal operational disturbances are not expected to jeopardize the future viability of the Chimney Rock eyrie.

Potential Alternative C gas development impacts on the Piedra River peregrine eyrie are also expected to be minor, because the eyrie is well buffered from the study area, hunting opportunities may be locally reduced in only a small portion of their presumed overall range, and habitats in the study area that are adjacent to the Piedra River, offering the best hunting opportunities, will be minimally affected by gas activities.

6.1.3 Black-footed Ferret

Black-footed ferrets are a federal- and state-listed "endangered" species that depends upon prairie dog (Cynomys spp.) colonies as a source of food and shelter (Hillman 1968, Henderson et al. 1969, Linder et al. 1982). Changes in land use practices and poisoning programs over the last century have reduced prairie dogs to one-seven hundredth of their former distribution (K. Fagerstone, USFWS, pers. comm.). As a result, all active prairie dog towns, or a complex of towns, large enough to support ferrets are considered potential black-footed ferret habitat (Clark et al. 1983, USFWS 1989). The only known extant ferret population, before ferrets were taken into captivity, was near Meeteetse, Wyoming; however, there may still be remnant populations in parts of their historic range (Clark et al. 1983). The HD Mountains study area occurs within the general historic range of the black-footed ferret (Bissell 1978a), although no black-footed ferret sightings have been confirmed in Colorado in recent years.

The western half of the HD Mountains study area supports a few small, widely separated colonies of Gunnison's prairie dogs (Cynomys gunnisoni). Under current black-footed ferret guidelines (USFWS 1989), surveys for ferrets are required for federal projects that impact black-tailed (C. ludovicianus) or white-tailed (C. leucurus) prairie dog towns or complexes greater than 80 or 200 acres, respectively. However, because the delineation of all prairie dog towns within the study area was beyond the present scope of work, it is unknown if a town or complex larger than 80 acres occurs in the study area or if any portion of that town or complex would be affected by the proposal. Surveys would also be required if a small town within the study area disturbed by the proposal were part of a complex mostly outside the study area. If ferret surveys are required, they should occur within one year of the proposed action. It is unlikely, however, that black-footed ferrets are present in the study area because the few, small, widely dispersed towns in the area would appear to provide an inadequate prey base.

Black-footed ferrets should not be affected under any of the three alternatives because (1) it is unlikely that they are present in the area, (2) suitable habitat/prey base (a sizeable prairie dog colony) appears to be lacking in the area, and (3) roads, flowlines, and well pads will not affect prairie dog towns. Facilities sitings will avoid prairie dog towns. If towns cannot be avoided, the proponent will notify the USFS before any impact occurs. If towns to be impacted require ferret surveys under current guidelines (USFWS 1989) they will be surveyed at appropriate times of the year and "cleared" before any construction occurs.

6.1.4 Colorado Squawfish

The Colorado squawfish is a federal and state endangered species in Colorado and New Mexico. Squawfish historically inhabited the San Juan River system downstream of the HD Mountains at the New Mexico border. No squawfish are known to presently exist above Navajo Dam, located approximately 30 miles downstream from the Piedra River side of the study area. However, a reproducing population of squawfish occurs in New Mexico downstream of the dam (D. Propst, NMGF, G. Skiba, CDOW, pers. comm.). Adult squawfish inhabit eddies, pools, and other areas adjacent to main current flows and move into main channel areas to feed (Haynes and Muth 1982, Woodling 1985). Diets change from primarily macroinvertebrates, during the first year, to fish when their total length approaches eight inches (Behnke and Benson 1980). Squawfish spawn in early to mid-summer over gravel bars in deep water. The same spawning sites are used year after year following long-distance migrations (Haynes and Muth 19832). Dams have blocked spawning migrations and have prevented adults from reaching suitable spawning sites. Cold water releases from dams are thought to have eliminated some historic spawning sites as fertilized eggs would not develop in the lower temperatures (Woodling 1985). Irrigation and channelization practices have lowered summer flows and decreased blackwater eddies used as nursery areas (Woodling 1985).

Colorado squawfish should not be adversely affected by implementation of any proposed alternative because (1) they are not known to occur above Navajo Dam (30 miles downstream the Piedra River), (2) there will be no local or downstream water depletions resulting from any alternative, (3) implementation of an effective operating plan will reduce erosion and the probability of accidental contamination (e.g., via storage tank failure) to acceptable levels, and (4) any sediments or contamination would be contained locally, quickly diluted, or, in the worst case, contained in Navajo Reservoir above the squawfish's occupied range.

6.2 FEDERAL CANDIDATE AND STATE THREATENED OR ENDANGERED SPECIES

Federal candidate species are sensitive wildlife species currently under consideration by the USFWS for addition to the "threatened" and "endangered" species lists. While there are no federal legal requirements to protect and/or avoid impacts to candidate species, the USFWS recommends avoiding such impacts to minimize potential economic loss or delay through project modification if the species is later listed or becomes proposed for listing during the planning process. Federal candidate species can, however, be protected under state laws, such as the Colorado Endangered Species Act.

6.2.1 Ferruginous Hawk

Ferruginous hawks are a federal candidate species and a Colorado species of "special concern" (Webb 1985). This buteo is most commonly associated with native or relatively undisturbed western plains where it hunts small rodents, especially prairie dogs, and ground squirrels, lagomorphs, and other prey. Call (1978) considered this species to be the most adaptable of any raptor in the selection of nest sites, which range from ground nests to tree nests to a wide variety of man-made structures. Ferruginous hawks are considered winter visitors in the Durango latilong block (Chase et al. 1982), the approximately 3,000 square mile area between 107-108° W longitude and 37-38° N latitude, which covers the study area.

No ferruginous hawks were noted during the brief field surveys through the study area (June 26-28, 1989), nor have any nests been reported in the area. Because this species is typically associated with open grasslands, the western third of the study area offers the most suitable habitat; the eastern two-thirds of the study area is primarily mountainous and forested with closed canopies, although relatively large open grasslands are locally available (e.g., in the extreme southeast corner of the study area near the mouths of Ignacio, Goose, and Turkey Creeks). How suitable the western third of the study area is for ferruginous hawks is, however, uncertain. Most of the former sagebrush/grasslands in this area have been converted into pastures and irrigated hayfields. With this agriculturalization, burrowing mammal communities, an important prey species, have been reduced by control programs. If habitat suitability is indicative of the seasonal presence of the species, the widely scattered prairie dog towns, lagomorph and small mammal populations, and carrion would apparently constitute an adequate winter prey base. The lack of breeding ferruginous hawks in the San Juan Basin may be more reflective of their low summer numbers in the area,

because areas of the basin appear to offer habitats as suitable as other areas in Colorado where they are common breeders.

Ferruginous hawks should not be adversely affected by any gas development alternative, because they are primarily winter visitors in the San Juan Basin and the acreage of suitable grassland habitats in the study area disturbed by gas activities will be relatively small.

6.2.2 White-faced Ibis

The white-faced ibis is a federal candidate species and Colorado species of special concern. Throughout their range, their numbers declined precipitously in the early 1970's because of pesticides (Terres 1980). They are considered migrants in the Durango latilong block, which overlaps the study area (Chase et al. 1982). White-faced ibis nest in colonies, usually in large stands of bulrushes or cattails, but they have also nested in heron colonies (Bent 1926). The closest known breeding area is at the Monte Vista National Wildlife Refuge where they are common breeders (USFWS 1982, Chase et al. 1982). During migration in Colorado, they are typically associated with mudflats and the littoral zone of ponds and lakes. The limited distribution of wet spring pastures and wetland habitats in and adjacent to the HD Mountains restricts the value of the area as a stopover point for the few ibis that migrate through the area. As a result, it is unlikely that implementation of any gas development alternative will adversely affect the ibis.

6.2.3 Long-billed Curlew

This largest member of the North American sandpiper family once nested throughout western and midwestern grasslands. It disappeared from many areas because of habitat losses resulting from plains and prairies plowed for agricultural purposes (Terres 1980). This federal candidate species and Colorado species of special concern (Webb 1985) is considered a migrant in the Durango latilong block (Chase et al. 1982); there are no records of nesting in the area. Bailey and Niedrach (1965) indicated that while this species was (and still is) a summer resident and migrant on Colorado's eastern plains, there were few west-slope records of their presence and they cited no records of breeding. During migration, curlews primarily inhabit wetlands, although some upland areas are also used. The few suitable wetlands present on the western slope of the HD Mountains and larger acreages of moist pastures offer habitat for migrating curlews; however, the relatively small area of these habitats and the apparently low numbers of curlews migrating through the

area suggest that the study area does not represent an important stopover area for migrants. As a result, it is unlikely that implementation of any gas development alternative will adversely affect the curlew.

6.2.4 Mexican Spotted Owl

The northern spotted owl (Strix occidentalis), one of three subspecies in the western United States, is a federal threatened species. The Mexican spotted owl (S. O. lucida) is a federal candidate species and the subspecies which enters Colorado. The species is not contained in the list of Colorado threatened and endangered species. The owl is addressed here because of USFS concern.

There are approximately 20 historical reports of the Mexican spotted owl in Colorado (Bailey and Niedrach 1965), 13 of which are considered valid by the Colorado Rare Bird Committee. Chase et al. (1982) considered the species to be a rare migrant present in only four of Colorado's 28 latilong blocks. There were no records of this owl's presence in the Durango latilong block, which overlaps the HD Mountains study area (Chase et al. 1982), although Gilman (1907) reported two in adjacent La Plata County in 1906 and the owl was considered a migrant in the adjacent Cortez latilong block (Chase et al. 1982). There are no verified nesting records for the state; however, the owl is considered a resident of Mesa Verde National Park (Davis 1969) and juveniles have been observed in the park (Colorado Field Ornithologists 1988).

Based on the limited number of spotted owl records in Colorado, little is known of their distribution and habitat use. Recent surveys in Arizona, New Mexico, and Utah (Ganey et al. 1988) have found the owl primarily in canyons or on steep mixed conifer, mixed broadleaf, and to a lesser extent, on spruce-fir slopes, ranging from approximately 3,300 to 9,800 feet. Reynolds (1989) surveyed 180 miles of transect in southwestern Colorado for spotted owls in 1989. Seven spotted owls were located: three in montane or mixed-conifer forests on steep slopes and four in steep-walled montane and pinyon-juniper canyons. One of these locations was in Sandoval Canyon, approximately six miles southeast of the Study Area on Southern Ute Indian Reservation lands. Habitats at the site were montane and pinyon-juniper forests on steep slopes.

Results of Reynolds' (1989) surveys and behavioral characteristics of the spotted owl suggest that the species is more common in Colorado than that indicated by historical records. The species is nocturnal and roosts during the day in forested canyons or on steep slopes where it is rarely seen. Most species of strictly nocturnal owls are only detected by vocalizations made during the breeding period. Unless specific nocturnal surveys are conducted in an area, biologists rarely know whether a particular species of owl is present. Despite the number of owls recently identified by Reynolds (1989), the species is uncommon in Colorado.

Based on the number of owls located in an estimated portion of suitable habitat, there may be approximately 20 spotted owls in Colorado, including only 5-6 territorial pairs (R. Reynolds, USFS, pers. comm.).

The steep mixed-conifer and montane slopes and canyons in the HD Mountains provide habitats ecologically similar to those at other southwestern Colorado sites occupied by the spotted owl. Reynolds (USFS, pers. comm.) did not survey the HD Mountains in 1989; however, he considers the area good spotted owl habitat. Without further study, the aforementioned study area habitats can be considered potentially suitable for the spotted owl. Suitable habitat, however, does not necessarily equate to occupied habitat. It is possible that spotted owls are present in the study area. A USFS funded study is now being conducted to determine if the Mexican spotted owl is present in the HD Mountains. Ongoing surveys have not yet detected the species (R. Bell, USFS, pers. comm.).

Potential spotted owl habitat would be adversely affected more by Alternative C than by Alternative A or B, because of the greater acreage of suitable habitats altered and the more protracted construction schedule. Implementation of Alternative A should have no adverse effects. Impacts associated with Alternative B would probably be minor because habitat losses would generally occur at lower elevations in less suitable spotted owl habitats.

6.2.5 North American Wolverine

The wolverine is a federal candidate species and Colorado endangered species (Bissell 1978b). Wolverines reach their southern distributional limits in Colorado, are scarce in other parts of the south central Rocky Mountains (Deems and Pursley 1978, Hall 1981, Wilson 1982, Nead et al. 1985), and were, apparently, never common in Colorado (Lechleitner 1969, Armstrong 1972). Wolverines may travel over 20 miles per day and range over large territories; male territories are as large as 772 square miles (Krott 1960, Nead et al. 1985). Males exclude other males from their territories, but permit females to enter (Ewer 1973).

The CDOW initiated a wolverine project in 1978 to summarize wolverine history in Colorado and to accumulate information about their current status (Nead et al. 1985). Although the study provided circumstantial evidence that wolverines were present in Colorado, it did not identify the presence of viable populations (Halfpenny 1981, Nead et al. 1985). Researchers associated with the project believe the species still exists in the state (Nead et al. 1985). Jim Halfpenny (Univ. of Colorado, pers. comm.) leader of the CDOW study, feels that the Wolf Creek Pass area (approximately 38 miles northeast of the study area) is the best place in the state to find wolverines.

Circumstantial evidence accumulated during the wolverine study suggested that during May through October, wolverines primarily occur at higher elevations from the upper montane to the alpine (Halfpenny 1981). Beginning around November, some wolverines may start an elevational migration to the lower limits of treeline or into the oakbrush-sagebrush zone, apparently in relation to migrating ungulate herds. Halfpenny (1981) speculated that management of ungulate winter range may benefit wintering wolverines and that the loss of winter range and reduced ungulate populations could have an adverse effect.

Wolverines have historically occurred in the vicinity of the study area (Armstrong 1972). Recent (within the last 20 years) unverified reports from trappers and others suggest that they may still persist in the general area (e.g., around Wolf Creek Pass and around Durango) (Halfpenny, pers. comm.). The HD Mountains provide winter range for deer and elk which summer in a large area to the north of U.S. Highway 160. Any wolverine(s) following these migratory herds could be attracted to the HD Mountains during big game winter range occupancy.

It is unknown, though unlikely, that wolverine are present in the study area. There have been no specific surveys for them in the HD Mountains, nor have there been any recently reported sightings. Wolverines were apparently uncommon in the area even before the arrival of white man, and, if present, they are undoubtedly less common today. If wolverines exist in the general area and if they follow migratory ungulate herds, they may seasonally occupy the HD Mountains, although they may not be present in all years. Although wolverine habitat requirements are poorly understood, if present, they would most likely utilize the area during winter.

It is unlikely that implementation of any gas development alternative would adversely affect the wolverine because there is no evidence that they are present in the study area. If present, they would probably be impacted to a minor degree by any proposed development. Potential impacts would be greatest under Alternative C, because of the potential for a slight long-term reduction in deer and elk numbers on and off the study area.

6.2.6 <u>River Otter</u>

River otters, a Colorado endangered species, are present in the Pine and Piedra Rivers and some of their tributaries as a result of CDOW transplants. Otters were formerly present in every major drainage in the state before being extirpated by beaver trapping and water pollution incidental to early mining efforts (Bissell 1978c). Habitat requirements include major waterways, with minimum flows of around 10 cubic feet per

second (cfs), and lakes that are open year-round. Habitats must have high water quality and contain an abundant supply of fish, amphibians, and crustaceans. The rivers and streams identified through CDOW WRIS mapping are considered "critical" habitat. Colorado designated "essential" or "critical" habitat is defined as any geographic area that is absolutely necessary for the maintenance or recovery of a threatened or endangered species (Torres et al. 1978).

The identified overall range of critical otter habitat meets the HD Mountains study area at the interface along Piedra River. However, no tributaries of the Piedra River draining the HD Mountains are known to support otters and the study area per se does not represent potential otter habitat. With the exception of Squaw and Beaver Creeks, which parallel U.S. Highway 160 along the study area's northern border, study area creeks are intermittent and do not support viable fisheries. The USFS considers the entire study area a non-fishery area (D. Cook, USFS, pers. comm.). Study area drainages are, however, tributaries of the Pine and Piedra rivers.

River otters should not be adversely affected by any gas development alternative. Potential impacts, which might affect the otter's food supply via sedimentation or water body contamination, should be reduced to acceptable levels by implementation of an effective operating plan. Other transplants into the Piedra River were made under the agreement between the USFS and CDOW that the USFS would not be required to alter any of its multiple use policies, such as gas development, to accommodate the otter (Browning and Wood 1978).

6.2.7 Roundtail Chub

Roundtail chubs are a federal "Notice of Review" species and a New Mexico endangered species (D. Propst, NMGF, pers. comm.); they have no special status in Colorado. Roundtails occupy slow moving waters adjacent to areas of faster river waters. Young-of-the-year prefer shallow river runs, while juveniles concentrate in river eddies and irrigation ditches (Valdez et al. 1982, Wiltzius 1978). Spawning occurs over a gravel substrate in early summer as spring runoff is subsiding (Valdez et al. 1982). Coldwater releases from reservoirs may have adversely affected roundtail reproduction by delaying or eliminating spawning and by reducing development of fertilized eggs (Woodling 1985).

Roundtails have historically been collected in the San Juan River above Navajo Reservoir (Woodling 1985) and they were found in the Reservoir shortly after dam closure (ca. 1962-63) (D. Propst, NMGF, pers. comm.). One roundtail, approximately 12 inches long, was caught in Navajo Reservoir by a fisherman in

1979 (M. Japhet, CDOW Fisheries Biologist, pers. comm). David Propst (NMGF, fisheries biologist, pers. comm.) and Mike Japhet think the species probably still occurs in some of the reservoirs tributaries, however, Mike Japhet (CDOW< pers. comm.) does not recall catching any in surveys of Navajo Reservoir tributaries.

If present in the Piedra River, adjacent to or downstream of the study area, potential impacts to the roundtail chub could include erosion caused sedimentation of spawning beds or contamination of the river resulting from accidents (e.g., a failure of a storage tank). Potential impacts would be most severe adjacent to the source before they were dispersed. However, with the implementation of measures in the operating plan, the likelihood of these impacts would be reduced to small possibilities. As a result, it is unlikely that implementation of any gas development alternative will adversely affect the roundtail chub.

6.2.8 Bonytail

The bonytail is a federal and Colorado endangered species. This fish was historically found throughout the Colorado River drainage, but is now rare in Colorado (Miller et al. 1982). One of the last specimens taken in the state was collected in 1984 from the Colorado River west of Grand Junction. The species prefers eddies and pools, not swift current (Vanicek and Kramer 1969). Lower water temperatures (resulting from reservoir releases) and hybridization have led to the decline of the bonytail (Woodling 1985). There is no evidence (museum records or survey results) that the bonytail ever existed in the San Juan River (D. Propst, NMGF, pers. comm.), although this river was probably within its historical distribution (Langlois 1978). The draft bonytail recovery plan, recently issued by the USFWS, will consider portions of the San Juan River in Colorado and New Mexico as possible recovery sites for the species if suitable habitats are located. The New Mexico portion of the San Juan River flows out of Navajo Reservoir. The Piedra and Pine rivers, which flank the HD Mountains to the east and west, respectively, flow into Navajo Reservoir. The Colorado portion of the San Juan River is also a tributary of Navajo Reservoir, but is isolated from the HD Mountains study area.

If present in reaches of the Piedra or Pine Rivers adjacent to the study area, or if the bonytail is reintroduced into these areas, implementation of any gas development alternative should not adversely affect the species because of the effectiveness of measures implemented as part of the operating plan.

7.0 SUMMARY

Amoco Production Company proposes to expand development of coal-bed methane gas extraction facilities in the HD Mountains. The U.S. Forest Service (USFS), as the lead federal agency, is preparing an Environmental Impact Statement (EIS) to evaluate the effects of different development alternatives. To comply with section 7(c) of the Endangered Species Act of 1973 (ESA), as amended, the USFS, as defined in the National Environmental Protection Act (NEPA), is required to obtain information from the U.S. Fish and Wildlife Service (USFWS) on any threatened or endangered species or critical habitat which may be present in the area of the proposed project. Furthermore, the USFS must submit to the USFWS a biological assessment that determines the effects of the project on the listed species.

This biological assessment has been prepared in accordance with the ESA. It addresses potential and likely impacts resulting from implementation of three gas development alternatives on the bald eagle, peregrine falcon, black-footed ferret, Colorado squawfish, ferruginous hawk, white-faced ibis, long-billed curlew, Mexican spotted owl, North American wolverine, river otter, roundtail chub, and bonytail. The conclusion of this assessment is that implementation of any of the proposed alternatives should have no significant adverse effect on current or future use of the area by any of the aforementioned federal or state threatened, endangered, or candidate species.

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